FORECASTING MUNICIPAL AND INDUSTRIAL WATER USE IN SOUTHWESTERN SKÅNE

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PREFACE

Water resource systems have been an important part of resource and environment related research at IIASA since its inception. As demands for water increase relative to supply, the intensity and efficiency of water resource management must be developed further. This in turn requires an increase in the degree of detail and sophistication of the analysis, including economic, social and environmental evaluation of water resource development alternatives aided by application of mathematical modeling techniques, to generate inputs for planning, design, and operational decisions.

This paper is a report on work carried out as part of a study of water resources management problems in South Western Skåne, Sweden, carried out in the years 1978-1981 by the Resources and Environment Area (REN) of IIASA in collaboration with the Department of Water Resources Engineering of the Lund Institute of Technology/University of Lund (LTH), Sweden. The study was initiated and pursued with the support of the Swedish National Environment Board, whose encouragement and financial assistance is gratefully acknowledged. The methodological work implemented within the framework of this study was generously supported by a grant from the Stiftung Volkswagenwerk, Hannover, Federal Republic of Germany.

Soon after initiation of the joint REN/LTH investigations, the Regional Development Task (RD) of IIASA engaged itself in a case study of economic and demographic, land use and related problems for the same region of Sweden. This work was pursued by the RD task in collaboration with the Southwest Skåne Municipal Board, as part of the Board's ongoing work on physical and public transport planning for the metropolitan region of Malmö and its neighboring municipalities. Because of the obvious relation between the studies pursued by the REN area and the RD task, both groups interacted intensively throughout the duration of their work. Moreover, it was agreed that analysis of "alternative futures" of water resource systems in Southwestern Skåne will take full advantage of the results of the RD studies concerning overall development prospects for the region, in particular projections of land use patterns.

The work presented embodies results of the land use projections developed by the Regional Development Task of IIASA.

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WATER USE PROJECTIONS IN SOUTHWESTERN SKÅNE

The projection in 1965 (SOU, 1965) of future municipal and industrial (M&I) water use in Southwestern Skåne (SWS), based upon water use trends before 1965, has proved to be in error since approximately 1970. Examination of water use practices in SWS since 1970 has revealed some of the reasons behind the erroneous projections. There are two main reasons behind the poor performance of the projections based on past trends. Both of these reasons are related to understanding the basic factors affecting water use in SWS. The first source of error was due to incorrect estimates of water use per unit of population and industrial production. The second source of error was a result of wrong assumptions in projecting future population and economic growth. These two errors were multiplicative, providing for a serious overestimation of total water use compared to actual use.

Per Unit Water Use

The errors related to per unit water use resulted from two factors. The first factor relates to industrial water use and was a result of new environmental protection legislation, which made discharging of effluents into receiving waters more expensive than recycling water. As a result of recycling, water intake decreased and intake water use per unit of production decreased.

The second factor relates to domestic water use. In the past, per capita water use grew as the standard of living increased and more water intensive activities and appliances became common. However, after the projections of 1965 were made, water use per capita reached a saturation level and stabilized at this level. As the per capita water use reached a saturation level, water prices started to rise to pay for some of the water supply projects needed to meet the projected use. As a result of these increased costs the population responded to the economic factors by reducing water use, and thus the price elasticity of water use became an important factor in projecting per capita water use.

Since Southwestern Skåne (Malmö county) consists of 20 municipalities, one of the major questions was how to account for differences among them in the total gross and sectoral municipal water use. Because of inadequacies in data bases (e.g. water use yearbooks comprise water production instead of metered water use data), statistical estimation of demand relationships proved to be difficult. Hashimoto and de Maré (1980) performed a study which provided some insight into the problem. It was found that industrial water use (based on municipal water supply) could be adequately defined as water use per employee for each industry and each municipality rather than per production unit. The study provided coefficients on water use per employee for most industries in SWS by municipality, for the water use conditions of 1975. The study also provided similar coefficients of water use per employee in the public sector by municipality, based on 1975 conditions. However, the study was not able to provide sufficiently detailed data on water use for domestic or household use. In 1980, another attempt was made toward better understanding of the domestic water use problem (Hanke and de Maré, 1982). This analysis was based on pooled, time series, cross section water demand samples from representative districts of Malmö (Malmö makes up 1/3 of the regional population). The analysis allowed the development of a model and estimates of price elasticities for residential (single family houses) water demand in Malmö. The Malmö data are representative for a number of other municipalities in SWS of similar demo-economic structure and the model developed for Malmö can be applied to these municipalities as well.

Demo-Economic Growth

As stated above, another reason for the poor predictive ability was an assumption that population and economic growth of SWS would continue at the same rates as in the past. However, due to many factors, such as world economic slow down, oil price increases, movement of urban population to the suburbs, and more, population in SWS has leveled off and in some municipalities population has even declined and the economy has become stagnant. Since the water use of SWS is very much linked to the demo-economic growth and structure of the region, any projection of future water use must be based upon reliable projections of industrial and public sector employment and population at the municipal level.

Soon after initiation of the REN/LTH investigations, the Regional Development Task (RD) of IIASA engaged itself in a case study of economic, demographic, land use and related problems for the same region of Sweden (Snickars et al., 1981). This work was pursued by the RD task in collaboration with the Southwest Skåne Municipal Board (SSK), as part of the Board's ongoing work on physical and public transport planning for the metropolitan region of Malmö and its neighboring municipalities. The results of the RD studies on "alternative futures" of demo-economic structure in SWS provided the necessary inputs to estimate future water use in SWS.

The following sections of this paper describe the procedure that was developed to project municipal and industrial water use in SWS to the year 2000, linking the work of the REN/LTH and the RD task. The goal of this work was to provide water use information for a detailed study of regional water demand/supply integration in SWS.

M&I WATER USE PROJECTION PROCEDURE

The work of the IIASA's Regional Development Task on land-use planning options in the Skåne region involved development and application of a hierarchical set of models (Snickars et al., 1981). Aggregate models were used as boundary conditions for a detailed analysis of demo-economic development in Skåne.

The most detailed analysis at the level of the municipality was carried out with application of a demo-land use planning model, ISP (for Interactive Spatial Planning developed by Roy and Snickars, 1982) for all of Skåne, but focusing on the area of SSK. This analysis divides the Skåne region into 35 separate sub-regions as shown in Fig. 1 and listed in Table 1. The sub-regions are defined by the degree of detail with which each municipality in Skåne is modeled. In some cases, a municipality may be represented by a few sub-regions, or a sub-region may be defined as an entire municipality or a sub-region may include a number of municipalities grouped together. The 9 municipalities that make up the planning region of SSK received the most detailed analysis and are modeled as 24 sub-regions, while the remaining municipalities of Skåne were modeled as 11 sub-regions.

For the analysis of future municipal and industrial water use in SWS, the REN/LTH case study focuses on the 12 municipalities that are connected to either the Ring or Vomb M&I water supply systems. These 12 municipalities are also the shareholders of Sydvatten (see Andersson et al., 1979 for description of M&I water supply systems in SWS and its planned extensions). Table 1 identifies 10 municipalities and two of them, Helsingborg and Landskrona, include the remaining two of Höganäs and Svalöv respectively (aggregation introduced by the land-use planning study).

The demo-economic structure of SWS is divided into 26 production sectors. For each of the 35 regions the model provides a forecast of the activity of each sector as well as the land use associated with each activity. As seen in Table 2, the sectors are divided into 7 production groups. In Group 1, sectors 1-4, represents agriculture and forestry (number of

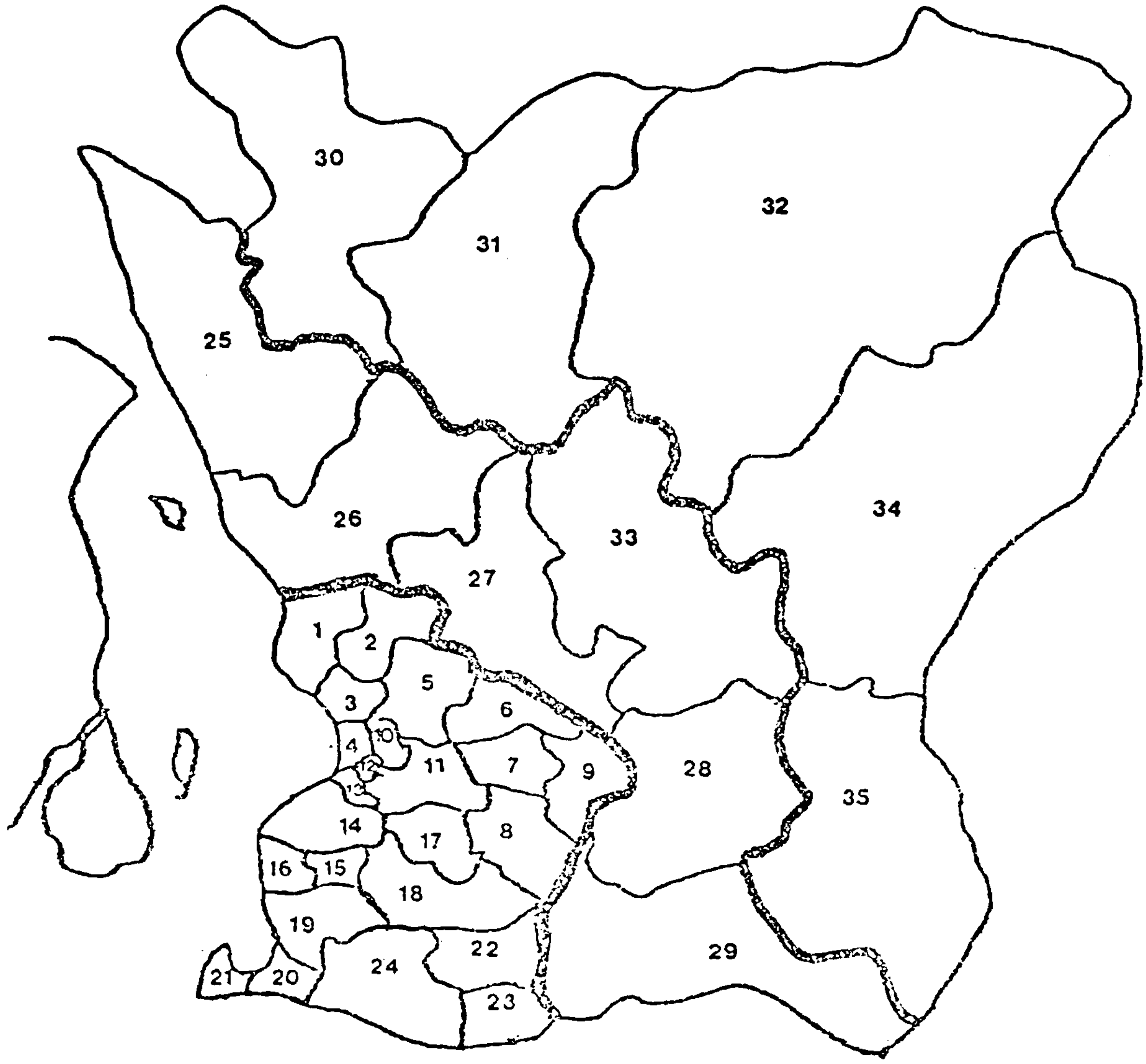

Figure 1. Zonal subdivision of Skåne for the land-use planning. The SSK region within left bold line (1-24), Malmöhus County (SWS) within the right (1-29).

Table 1. Subregion divisions for the Skåne study.

Sub-Regions

			Group	
1.	Löddeköpinge	- lodd	1	1
2.	Kävlinge	- kavl	1	
3.	Bjärred	- bjar	2	2
4.	Lomma	- lomm	2	
5.	Lund	- lund	3	3
6.	Södra-Sandby	- sand	3	
7.	Dalby	- dalb	3	
8.	Genarp	- gena	3	
9.	Veberöd	- vebe	3	
10.	Hjärup	- hjar	4	4
11.	Staffanstorp	- staf	4	
12.	Akarp	- akar	5	5 (Burlöv)
13.	Arlöv	- arlo	5	
14.	Malmö	- malm	6	6
15.	Oxie	- oxie	6	
16.	Bunkeflo	- bunk	6	
17.	Bara	- bara	7	7
18.	Svedala	- sved	7	
19.	Vellinge	- vell	8	
20.	Höllviks-Näs	- boll	8	
21.	Skanör	- skan	8	
22.	Anderslöv	- ande	9	
23.	Smygehamn	- smyg	9	
24.	Trelleborg	- trel	9	
25.	Helsingborg	- hels	10	9 (incl. Höganäs)
26.	Landskrona	- land	10	10 (incl. Svalöv)
27.	Eslöv	- eslo	10	8
28.	Sjöbo	- sjob	10	
29.	Ystad	- ysta	10	
30.	Ängelholm	- ange	10	
31.	Klippan	- klip	10	
32.	Hässleholm	- hass	10	
33.	Hörby	- horb	10	
34.	Kristianstad	- kris	10	
35.	Simrishamn	- simr	10	

Note: The numbers to the far right identify the municipalities included in this study. Location of individual sub-regions is identified in Fig. 1.

Table 2. Production sectors for the Skåne study.

Production Sectors

			Group	
1.	Crop production	- crop	1	
2.	Meat production	- meat	1	
3.	Vegetable production	- vege	1	
4.	Forestry	- fore	1	
5.	Food industry	- food	2	Industrial water use
6.	Chemical industry	- chem	2	Industrial water use
7.	Equipment industry	- equi	2	Industrial water use
8.	Other industry	- othe	2	Industrial water use
9.	Utilities	- util	3	Industrial water use
10.	Petroleum industry	- petr	3	Industrial water use
11.	Wholesale trade	- whol	4	
12.	Retail trade	- reta	4	
13.	Private services	- priv	4	
14.	Single family housing	- sing	5	Domestic water use
15.	Multi-family housing	- mult	5	Domestic water use
16.	Education	- educ	6	Public sector water use
17.	Health care	- heal	6	Public sector water use
18.	Public administration	- publ	6	Public sector water use
19.	Roads	- road	7	
20.	Railways	- rail	7	
21.	Harbours	- harb	4	
22.	Airports	- airp	4	
23.	Person transport	- pers	4	
24.	Goods trasnsport	- good	4	
25.	Recreation	- recr	7	
26.	Coast	- coas	7	

Production Groups

1. Agriculture - agrb
2. Industry - indb
3. Energy - eneb
4. Service - serb
5. Housing - houb
6. Government - govb
7. Slack - slab

persons employed and the corresponding land use). Group 2, sectors, 5-8, make up the industrial portion of the economy (number of persons employed and the land use) Group 3, sectors 9-10, represent the energy supply (numbers of persons employed and the land use.) Group 4, sectors 11-13, and 21-24, represent the private services (number of persons employed and the land use.) Group 5 represents dwellings. Sector 14 represents the population living in single family dwellings (number of persons and the land use) and sector 15 represents the number of persons living in multi-family dwellings. Group 6 is public services, sector 16 - education and research employment, 17 - employment in the health care sector, and 18 - the remainder of public employment. Group 7, sectors 19-20 and 25-26, represents transport and recreational activities with its activity expressed in land use only.

Inputs from the higher models in the hierarchy provide the data that drive the ISP model. The model is run with a time step of 5 years starting in 1975 and continuing to 2000. Performance indicators are generated at each time step, for each of the 26 sector activities, and each of the 35 regions.

The results produced by the ISP model are directly employed for the M&I water use projections. The demo-economic activities that influence M&I water use are divided into three categories, industrial use, public sector use and domestic use. These three categories identified in Table 2 are sub-sets of the 26 sector activities of the ISP model. The water use projections are calculated by multiplying the projected levels of activity in each of three water use categories by water use coefficients (per employee, per person, for a given percentage of water use supplied by the regional M&I supply system) estimated on the basis of past water use records.

Finally, the total water use for each region and for each time step is calculated as the sum of the industrial, public and domestic water.

The results for the specific water use categories or for the total water use can be aggregated at different levels, specified in the data input. The options allow for data to be displayed at the regional level, aggregated at the municipal level for predetermined groupings, with the remaining regions lumped as a single value, or the total water use summed for the whole region. These results can be displayed in tables or in graphical form for all the time steps.

WATER USE COEFFICIENTS

For water use projections, estimates of water use coefficients for the sector activities projected by the ISP model must be calculated.

To provide a consistent set of data which corresponds to the ISP output, the 1975 background data for the ISP model was combined with water use data provided by the detailed analysis of 1975 water use in SWS (Hashimoto and de Maré, 1980) to estimate water use coefficients. However, this did not provide sufficient detail on domestic water use and another study by Hanke and de Maré, (1982) was undertaken to examine this water use category in more detail.

Industrial Water Use Coefficients

Although the industrial water use data developed by Hashimoto and de Maré (1980) included water use per employee for various industrial sectors, the division of these sectors was not the same as the one adopted in the ISP model. Therefore, industrial employment for all industrial activities from the 1975 ISP reference data was summed for each municipality and this information was combined with the total industrial water use by municipality, estimated by Hashimoto and de Maré (1980). These data jointly provided a mean water use per industrial employee for each municipality. This data is presented in Table 3.

Table 3. 1975 Industrial Reference Data.

No.	Municipality	1975 Industrial Employment	1975 Industrial Water Use (MCM)	Annual Water Use (M^3/emp)
1	Kävlinge	3173	0.649	204.50
2	Lomma	1216	0.146	120.07
3	Lund	9495	0.816	85.94
4	Staffantorp	1557	0.561	360.30
5	Burlöv	3000	0.311	103.30
6	Malmö	43841	4.853	110.7
7	Svedala	1513	0.063	41.64
8	Eslöv	4809	1.053	218.96
9	Helsingborg Höganäs	19856	5.751	289.64
10	Landskrona Svalöv	12122	1.354	111.7

The aggregation of all industrial activity does lose some accuracy. However, most municipalities are dominated by one industry or have a stable mix of industries that should remain in the same proportion (Ohlsson, 1982). The projection procedure allows for the variation of water use among municipalities which is of prime importance in this analysis. The reason that there are large variations between some of the regions is that some regions are dominated by a single industry which has a very low total water use. Further, in some regions more of the industrial water is self-supplied than in other regions. Moreover, it should be noted that the coefficients developed this way refer to the industrial water supplied by the M&I system only (industrial water supplied by other sources, e.g., wells owned by individual industrial plants are not reflected in the coefficients).

Public Sector Water Use Coefficients

Similar to the industrial water use data, the public sector water use data is presented by Hashimoto and de Maré (1980) as total water use for the public sector and does not fit the structure of the ISP model. Thus, total public sector employment was obtained from the 1975 ISP data and total public sector water use for 1975 was obtained from Hashimoto and de Maré (1980). By combining these two sets of data, a mean water use per public sector employee, per municipality, was calculated. These data are presented in Table 4. All water for public sector use is assumed to come from the M&I water supply system.

Table 4. 1975 Public Sector Reference Data.

No.	Municipality	1975 Public Employment	1975 Public Water Use (MCM)	Annual Water Use (M^3/emp)
1	Kävlinge	1166	0.171	146.70
2	Lomma	1138	0.171	281.00
3	Lund	19073	3.446	180.70
4	Staffantorp	703	0.221	314.40
5	Burlöv	837	0.416	497.00
6	Malmö	30839	6.369	206.50
7	Svedala	234	0.157	235.00
8	Eslöv	2126	0.589	281.30
9	Helsingborg Höganäs	12693	2.965	233.60
10	Landskrona Svalöv	4007	1.083	270.3

The employment in the public sector represents many types of public enterprises, from hospitals to universities. In a small region such as SWS these facilities tend to be located in a single region. As a result, the public sector water use of a region will be dominated by the water use characteristics of the major public facility that is located in the region. For example, if a public research facility with few employees, but large water use is located in a region with little other public employment, then the water use per public employee will be rather high compared to other regions.

Domestic Water Use Coefficients

Domestic water currently accounts for more that 60% of total M&I water use in the 12 municipalities of the study. The treatment of domestic water use as total domestic use per municipality was considered insufficient, and it was decided to take advantage of a detailed study of water use in single family dwellings in Malmö (Hanke and de Maré, 1982). This study produced a statistical model of per capita water demand for single family dwellings applicable to other municipalities of SWS that have similar characteristics as Malmö.

The ISP model divides the population of SWS into those living in single family dwellings and those in multi-family dwellings. From the 1975 ISP data (Snickars et al., 1981) the total number of people in each category was obtained. Given the total number of people connnected to the municipal supply system (Hashimoto and de Maré, 1980), and assuming that all multi-family dwellings are connected to the M&I supply system, then the percentage of single family dwellings connected is found.

The Hanke-de Maré model for per capita single family water use was developed using data from the Malmö municipality where over 99 percent of the population live in an "urban setting". It was assumed that the Hanke-de Maré model was valid for the municipalities of SWS in which the percentage of the population living in an urban setting was 90 percent or greater. With the number of persons in single family dwelling connected to the municipal system in 1975 and the model for per capita water demand, total single family water use can be determined for those municipalities for which the demand model holds true. The difference between the total domestic water use and the total single family use is total multi-family use. With the number of persons living in multi-family dwellings and connected to the municipal system known for 1975, a per capita water use for multi-family dwellings can be obtained.

The estimates of multi-family water use for those municipalities where the Hanke-de Maré model was valid showed little variation (see Table 5). Based on the analysis and discussion with local officials, it was concluded that per capita water use in multi-family dwellings is very similar throughout Skåne, while single family per capita water use varies, depending on the urban/rural mix of municipality. For the municipalities where the Hanke-de Maré model was invalid, per capita multi-family water use was assumed to be 240 liters per person and single family water use was determined by the water balance.

Table 5. 1975 Domestic Water Use Reference Data.

No.	Municipality	1975 Domestic Water Use (MCM)	Single Family Water Use (l/person-day)	Multi Family Water Use (l/person-day)
1	Kävlinge	1.088	167.0	240.0
2	Lomma	1.133	165.9	240.0
3	Lund[1]	4.806	128.1	221.7
4	Staffanstorp	0.918	171.0	240.0
5	Burlöv[1]	1.003	140.3	236.8
6	Malmö[1]	19.108	138.5	240.8
7	Svedala	0.410	135.9	240.0
8	Eslöv[1]	1.195	133.8	200.0
9	Helsingborg[1] Höganäs[1]	8.313	134.5	242.7
10	Landskrona[1] Svalöv[1]	2.923	135.4	236.8

[1]Based on the Hanke-de Maré model

TRENDS IN WATER USE

In the sections above, the procedure to determine a consistent set of water use coefficients reflecting the 1975 situation was described. However, no mention was made about how to determine coefficients for the other time periods of the projection up to the year 2000. The data on water use in SWS provided by Andersson et al. (1979), Hashimoto and de Maré (1980), and Hanke and de Maré (1982), has provided good insight into the factors affecting water use. Based upon these data it was assumed that the water use coefficients for SWS will remain at the 1975 level up to the year 2000.

There is some evidence to substantiate this assumption. First, since 1975 the per capita water use for domestic and public sectors has remained effectively stable. Data from the municipality of Helsingborg, Table 6, shows that for the years 1975 through 1980, the average daily water use per capita for domestic use and for combined public and domestic use has exhibited no upward or downward trend.

Table 6. 1975-1980 Water Use Data for Helsingborg.

	1975	1976	1977	1978	1979	1980
Domestic Use[1]	178	178	182	174	171	176
Domestic & Public Use	277	282	269	265	272	274

[1]Liters per person per day

There is no detailed data on industrial water use for Helsingborg, but industrial employment and water use has been decreasing. It is generally believed that this decrease is due to decreased economic activity and the delayed effects of the environmental legislation. It is believed that the per unit industrial water use will stabilize in the future. Direct discussion with SWS municipalities confirm these arguments concerning future unit water use; however much less certainty exists on the demo-economic growth of the region. With no major changes evident in the data up to 1981, the 1975 data appear to be a sound basis for future projections. The choice of the 1975 data is felt to be a conservative estimate, since technological developments will most likely provide for reductions in unit water use.

There is much less certainty about the future of the economy of SWS. To overcome this difficulty, a range of economic forecasts or scenarios are examined. These scenarios are input to the ISP model for projections of dynamic disaggregate estimates of economic activity and population.

DEMO-ECONOMIC GROWTH AND RELATED WATER USE PROJECTIONS

The scenario approach was taken for analysis of a long term demo-economic growth of Skåne. Starting with 1975 as a base point, three scenarios for demo-economic growth to the year 2000 were developed and their brief description taken from Snickars et al., (1981) follows.

> *The Base Scenario*. The development in Sweden and in the Skåne region follows the base forecast with a population increase to the year 2000 of 50,000 in Skåne. Total industrial employment in the region does not increase over the 25 year planning horizon. Most industries have a reduction in the number of employees, while the chemical industry experiences a growth of 1,000 employees. The employment in the agricultural industry decreases by 10,000 persons while at the same time increasing productivity. The public service employment continues its steady growth, with a growth of 54,000 employees by the year 2000.
>
> *The Industry Scenario*. The development in Sweden and in the Skåne region proceeds along the forecasts in the policy-action alternative in the 1980 Long-Term Economic Report (SOU, 1980) and extensions of these forecasts. The population of Skåne grows by 70,000 - 90,000 until the year 2000. This population growth is paralleled by an increase in total employment of 80,000 persons. The employment in the industrial sector grows by 30,000 with most growth coming in the chemical and equipment industries. Agriculture employment decrease by 13,000 and the public sector growth is at the same level as the base alternative, 54,000.
>
> *The Public Sector Scenario*. The development in Sweden and the Skåne region follow the forecasts in the laissez-faire alternative of the 1980 Long-Term Economic Report (SOU, 1980). The population in Skåne increases by 30,000 - 40,000 until the end of the century with total employment growth between 30,000-40,000. The industrial employment decreases by 23,000 and agriculture employment decreases by 15,000 in the year 2000. An additional 90,000 persons are employed by the public sector.

Each of these scenarios produced estimates of activity in the 26 micro-sectors, for the 35 regions and for each time step of the ISP model. From these results M&I water use projections are made.

RESULTS

A comparison of the M&I water use projections from the three scenarios for total M&I water use for the twelve municipalities (combined Vomb & Ring systems) is presented in Figure 2 and Tables 7 and 8. Detailed data for each of the twelve municipalities for each of the scenarios and by use category is presented in tabular form in the appendix to this paper.

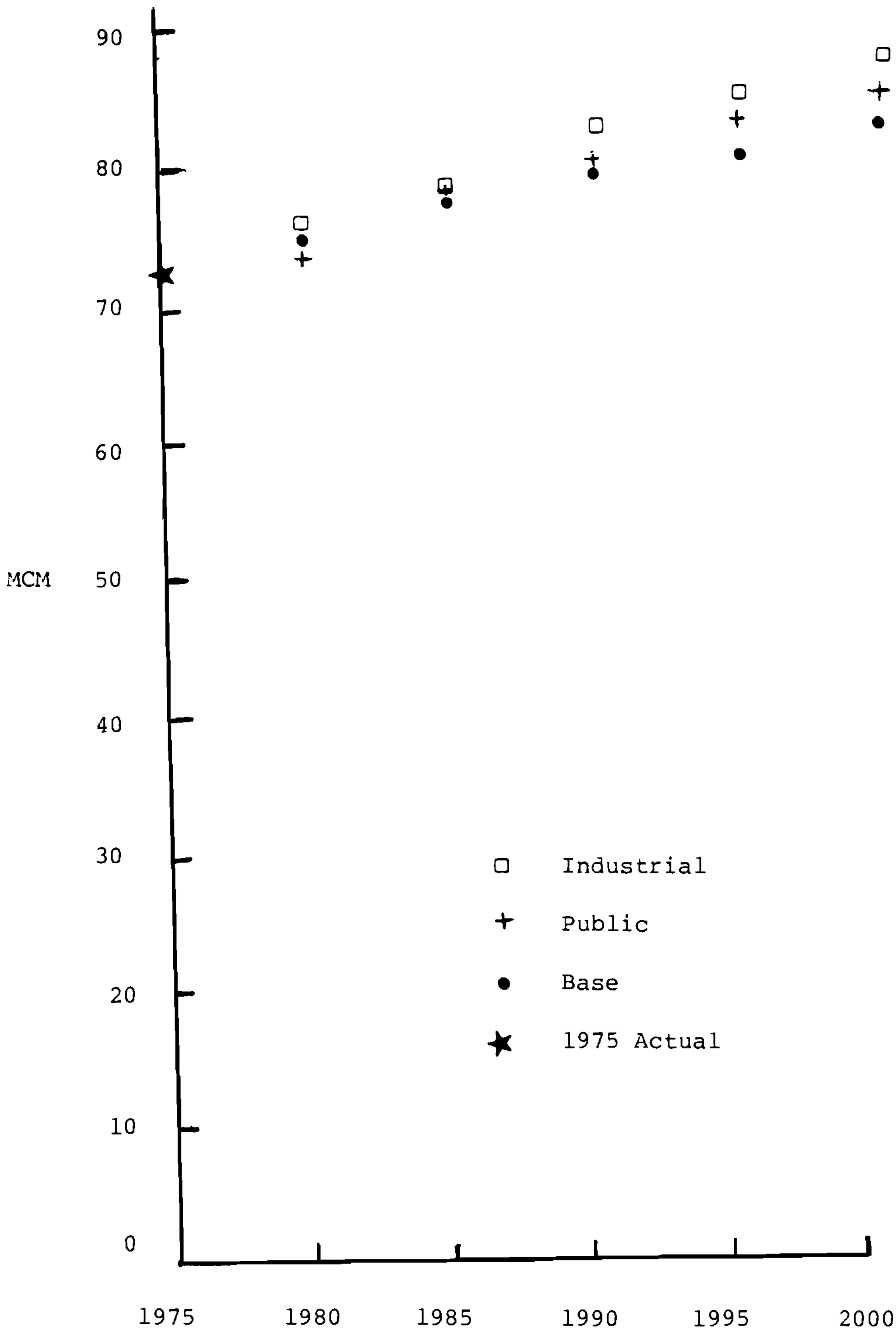

Figure 2. Projected M&I Water Use in Southwestern Skåne.

Table 7. Total M&I Water Use Projections - 2000.

Scenario \ Water Use	Industrial	Domestic	Public	Total
	MCM	MCM	MCM	MCM
Industrial	17.817	42.829	26.345	86.991
Public	12.769	41.409	30.641	84.820
Basic	14.749	41.899	26.047	82.697
1975 Data	15.557	40.897	15.597	72.051

Table 8. M&I Water Use Structure - 2000.

Scenario \ Water Use	Industrial	Domestic	Public
	% of Total Water Use		
Industrial	20.5	49.2	30.3
Public	15.1	48.8	36.1
Basic	17.8	50.7	31.5
1975 Data	21.5	60.0	18.5

An important result is that for the most water intensive industrial scenario, there is only a 21% increase in the total water use between 1975 and 2000, while for the base scenario with lower economic growth projections a 15% increase in water use is projected for the same time period. This is significant because over the previous 25 years, 1950-1975 water use for the twelve municipalities more than doubled.

Examining the water use projection from the three scenarios together, one can see that the projections are very close up until the year 1985, after which they start to diverge. Even with this divergence, the range between the highest and lowest projections in the year 2000 is only 6%. Such a small range is well within the accuracy of projections 25 years into the future. This result would seem to imply that should any of these scenarios actually occur, then the M&I water management policy to follow in each case would be similar.

To understand the factors contributing to this growth in total water use, the various components of water use should be examined. Figure 3 is a plot of the projected industrial water use for the municipalities studied. As would be expected, the industrial scenario shows the most growth in industrial water use from 15.6 MCM in 1975 to 17.9 MCM in 2000.

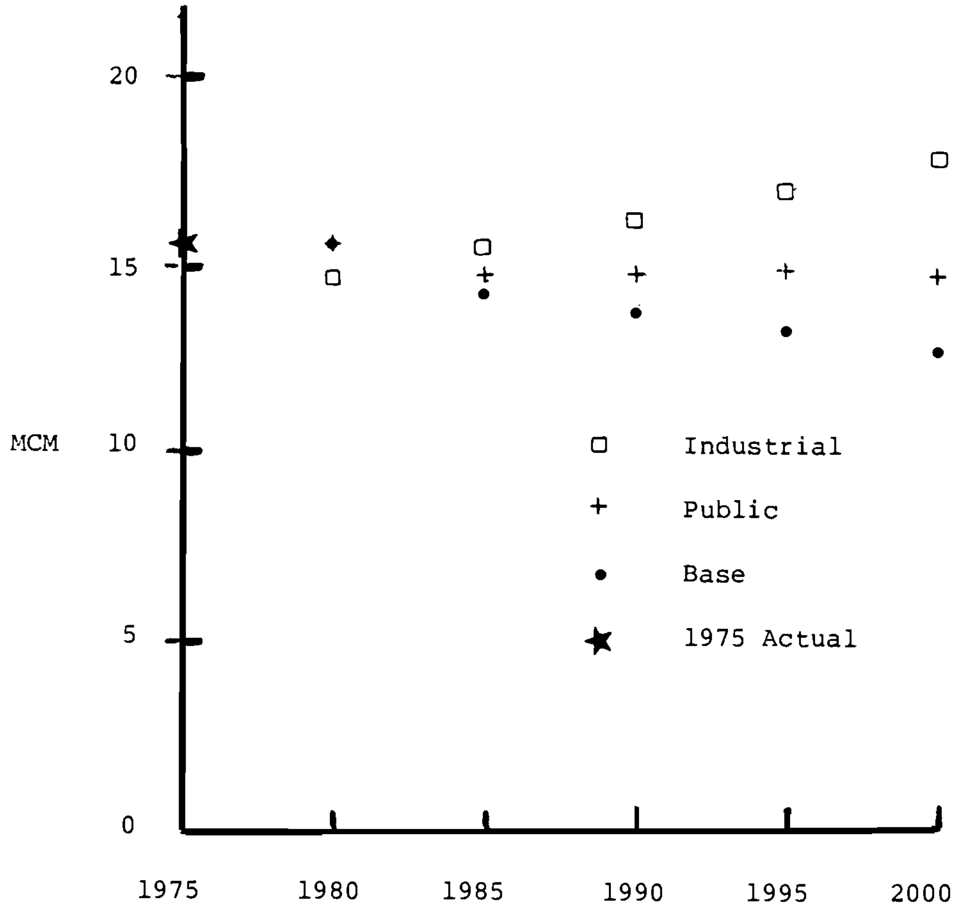

Figure 3. Projected Industrial Water Use in Southwestern Skåne.

This 2.3 MCM increase accounts for approximately 15% of the total water use increase for the industrial scenario. In the public sector and base scenarios industrial water use decreases.

Total domestic water use projections for the Vomb/Ring system is shown in Figure 4. The growth is almost identical for all three scenarios. In the scenario with the largest domestic water use increase, the industrial scenario, there is an increase of 1.6 MCM over the 25 year period which amounts to about 11 percent of the growth in total water use for the system. In the other scenarios the percentage of the total increase is less.

The projection of public sector water use exhibits the most growth of all the sectors in all the scenarios. A comparison of the public sector projections is presented in Figure 5. In the case with the smallest growth, public sector water use increases 67 percent over 1975 and in the public sector alternative the projection of public sector water use in 2000 is 97 percent more than in 1975.

What this analysis has shown is that a major shift in the structure of M&I water use for SWS is projected. In 1975 the structure of M&I water use supplied by the Vomb/Ring system was industrial use-21.5 percent, domestic-60 percent, and public sector-18.5 percent. Tables 7 and 8 provide comparison on the structure of M&I water use for the Vomb/Ring system for 1975 and the three scenario projections in volumes and percentages. The public sector is the major activity responsible for projected growth of M&I water use in SWS. In the industrial scenario, public sector use accounts for 74 percent of the total M&I increase. In the base and public sector water use contributes 102 and 121 percent of the total M&I increase, respectively. The percentages can be greater than 100 percent due to decreases in the industrial water use and insignificant growth in the domestic use.

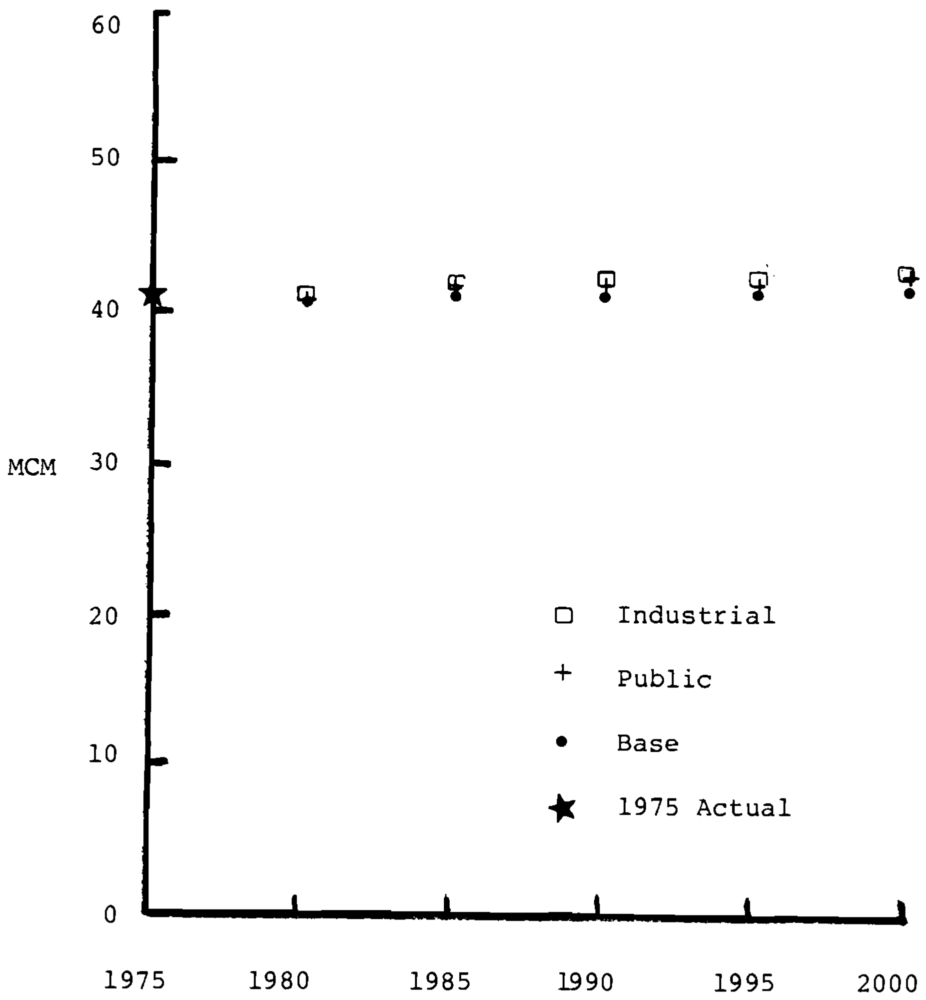

Figure 4. Projected Domestic Water Use in Southwestern Skåne.

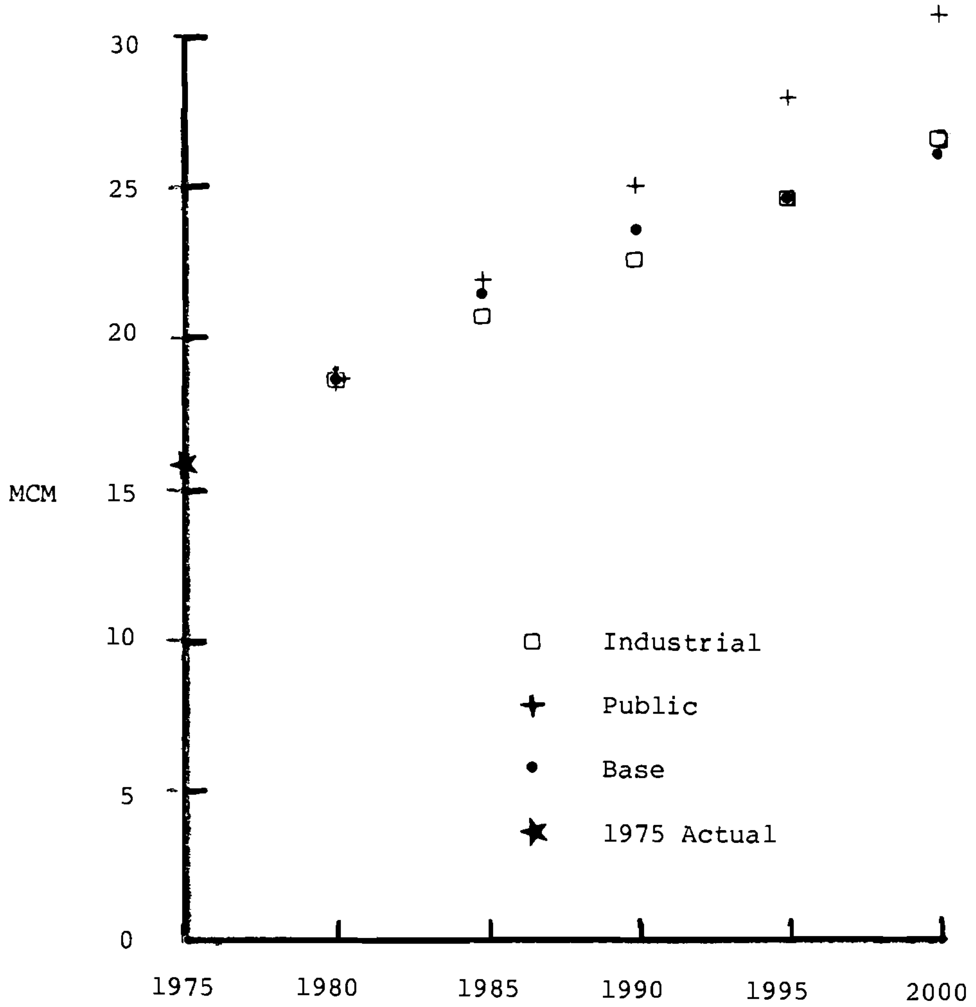

Figure 5. Projected Public Sector Water Use in Southwestern Skåne.

SUMMARY

The M&I water use projections and preceding analysis have shown that even under the most water intensive demo-economic growth scenario for Skåne, the total M&I water use for the 12 municipalities of interest is projected to increase only 21 percent from 1975 to 2000. This growth is almost entirely a result of growth in public sector use. This result generates two important points.

1) The public sector as a major user of M&I water supply is a rather recent phenomenon in Skåne. It has exhibited steady growth over the past years and, as the projections show, will most likely continue in the future. This causes some concern since the public sector is the least studied of the water use sectors in Skåne and the changes in size are far from marginal. Little is known of public sector water demand.

2) Public sector employment and production growth, and therefore, public sector water use, are a function of government policy. This implies that the growth of public sector water use can be radically changed as a result of government policy, making long range projections of public sector activity even more uncertain than population growth and at least as uncertain as industrial growth. These results in addition to providing data on future water use for the study of regional water demand/supply integration, reveal the need to study public sector water use in more detail as it may become the important factor determining future needs for increased regional water supply.

APPENDIX A.

Table A1. 1975 M&I Water Use Data.

NO.	MUNICIPALITY	INDUSTRIAL MCM	DOMESTIC MCM	PUBLIC MCM	TOTAL MCM
1	KÄVLINGE	0.649	1.088	0.171	1.908
2	LOMMA	0.146	1.133	0.171	1.450
3	LUND	0.816	4.806	3.446	9.068
4	STAFFANTORP	0.561	0.918	0.221	1.700
5	BURLÖV	0.311	1.003	0.416	1.730
6	MALMÖ	4.853	19.108	6.369	30.330
7	SVEDALA	0.063	0,410	0.157	0.630
8	ESLÖV	1.053	1.195	0.598	2.846
9	HELSINGBORG HÖGANÄS	5.751	8.313	2.965	17.029
10	LANDSKRONA SVALÖV	1.354	2.923	1.083	5.360
	TOTAL	15.557	40.897	15.597	72.051

Table A2. Industrial Scenario Water Use Projections - 2000.

NO.	MUNICIPALITY	INDUSTRIAL MCM	DOMESTIC MCM	PUBLIC MCM	TOTAL MCM
1	KÄVLINGE	0.750	1.201	0.271	2.222
2	LOMMA	0.098	1.109	0.520	1.727
3	LUND	0.766	5.215	6.150	12.131
4	STAFFANTORP	0.636	1.034	0.398	2.068
5	BURLÖV	0.342	1.031	0.711	2.084
6	MALMÖ	4.010	18.572	9.698	32.280
7	SVEDALA	0.069	0.828	0.397	1.294
8	ESLÖV	1.495	1.349	1.039	3.883
9	HELSINGBORG HÖGANÄS	7.911	9.250	5.249	22.410
10	LANDSKRONA SVALÖV	1.740	3.239	1.912	6.891
	TOTAL	17.817	42.829	26.345	86.991

Table A3. Public Scenario M&I Water Use Projections - 2000.

NO.	MUNICIPALITY	INDUSTRIAL MCM	DOMESTIC MCM	PUBLIC MCM	TOTAL MCM
1	KÄVLINGE	0.649	1.193	0.300	2.142
2	LOMMA	0.093	1.104	0.563	1.760
3	LUND	0.670	5.067	6.980	12.717
4	STAFFANTORP	0.589	1.028	0.452	2.069
5	BURLÖV	0.589	1.028	0.452	2.069
6	MALMÖ	3.363	18.017	11.096	32.476
7	SVEDALA	0.058	0.816	0.413	1.287
8	ESLÖV	0.894	1.281	1.292	3.467
9	HELSINGBORG HÖGANÄS	4.971	8.816	6.459	20.246
10	LANDSKRONA SVALÖV	1.178	3.082	2.358	6.618
	TOTAL	12.760	41.409	30.641	84.820

Table A4. Base Scenario M&I Water Use Projections - 2000.

NO.	MUNICIPALITY	INDUSTRIAL MCM	DOMESTIC MCM	PUBLIC MCM	TOTAL MCM
1	KÄVLINGE	0.680	1.197	0.257	2.134
2	LOMMA	0.095	1.107	0.505	1.707
3	LUND	0.701	5.112	5.920	11.733
4	STAFFANTORP	0.609	1.031	0.379	2.019
5	BURLÖV	0.318	1.015	0.700	2.033
6	MALMÖ	3.593	18.226	9.694	31.513
7	SVEDALA	0.062	0.816	0.378	1.256
8	ESLÖV	1.158	1.304	1.044	3.506
9	HELSINGBORG HÖGANÄS	6.152	8.955	5.257	20.364
10	LANDSKRONA SVALÖV	1.382	3.136	1.914	6.432
	TOTAL	14.749	41.899	26.047	82.697

REFERENCES

Andersson, Å.E., P. Hjorth, L. de Maré, and A.S. Thelander. 1979. Water Resources Planning and Management in Advanced Economies: The Case Study of Western Skåne, Sweden - A Background Report. WP-79-23. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Anderson, R.J. 1980. The Probability Distribution of Water Inputs and the Economic Benefits of Supplementary Irrigation. WP-80-165. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Anderson, R.J. 1981. An Economic Analysis of Supplementary Irrigation in Skåne. RR-81-33. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Hanke, S.H., and L. de Maré. 1982. Residential Water Demand A Pooled, Time-Series, Cross-Section Study of Malmö, Sweden. WP-82- . Laxenburg, Austria: International Institute for Applied Systems Analysis.

Hashimoto, T., and L. de Maré. 1980. Municipal Water Demand Study of Western Skåne, Sweden. Background Analysis with Some Preliminary Results. WP-80-76. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Ohlsson, L. 1982. Industrial Structure and Possible Industrial Futures of the Malmöhus County. CP-82-19. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Roy, G.G., and F. Snickars. 1982. An Introduction to the "I.S.P." System for Land Use Planning. WP-82-70. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Snickars, F. 1981. Comparative Studies of Regional Planning Models with Special Emphasis on a Case Study of South Western Skåne. WP-81-48. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Snickars, F., Å. Andersson, I. Holmberg, B. Marksjö, G. Roy, J. Schultz, and U. Strömkvist. 1981. Economic Development and Land-Use in Southwestern Skåne. A Case Study of Regional Systems Analysis for Physical Planning. Presented at the Applied Regional Systems Analysis - Conclusions from Case Studies in Bulgaria, Poland, and Sweden Conference from 2-4 November 1981. Laxenburg, Austria: International Institute for Applied Systems Analysis.

SOU 1965:8. 1965. Skånes och Hallands Vattenforsorjning. Ministry of Communications, Stockholm, Sweden.

SOU. 1980. Swedish Long-Term Economic Report (in Swedish). Ministry of Communications, Stockholm, Sweden.