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THE REGIONAL CONTEXT OF INDUSTRIAL WATER DEMAND FORECASTING IN CANADA

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SYNOPSIS

The problems of adapting aggregate socio-economic forecasts to river basin regions are discussed. The latest results of Canadian water use surveys are also outlined and show that Canadian manufacturing in 1976 had a total intake of about 8,700 billion liters. The methodology for industrial water demand forecasting in Canada is outlined in the final section of the paper.

RESUMÉ

On étudie, dans le présent document, les difficultés que comporte l'adaptation des prévisions socio-économoniques d'ensemble aux régions renfermant des bassins fluviaux. On y présente également les plus récentes données recueillies sur les utilisations de l'eau au cours de relevés effectués au Canada et, selon lesquels, la consommation totale du secteur manufacturier canadien aurait totalisé près de 8,700 milliards de litres en 1976. On trace, au dernier chapitre, les grandes lignes de la méthodologie établie afin de prévoir la demande en eau du secteur industriel canadien.

RESUMEN

Se exponen los problemas de la aplicación de pronósticos socio-económicos globales a las regiones de las cuencas de los ríos. Los últimos resultados de los estudios canadienses de la utilización del agua se describen igualmente e indican que la manufactura canadiense en 1976 ha registrado un insumo total de aproximadamente 8,700 litros. La metodología para la predicción de la demanda de agua industrial en Canadá se expone en la sección final de la ponencia.

The aggregate abundance of water in Canada has placed water demand forecasting into an inferior position in the milieu of water management studies. With about 9% of the world's total freshwater runoff and less than 1% of the world's population, Canadian water managers have been slow to perceive the need for water demand forecasting, and have tended to devote their main efforts to studies resulting in supply manipulation. However, frequent regional water shortages, particularly in the drier Western interior of the country, have kindled some interest in this subject, and there are now a small number of researchers, both within and outside the government service, actively pursuing water demand forecasting studies.

This paper briefly examines efforts in the federal government to carry out investigations in industrial water demand forecasting. This outline does not contain all of the Canadian efforts, but, we believe, is fairly representative. Two principles have underlain these efforts to data: theoretical correctness and the practicalities of limited budgets, manpower, and the like.

An Overview of Past Studies

The initial national attempt to quantify future industrial water demands was made by Cass-Beggs[1] in a study for the federal Resources for Tomorrow conference in 1961. The study, while succeeding in its primary objective to provide an outlook on the future, was methodologically quite crude, basing its estimates on constant water use coefficients. The next major piece of research was carried out through a seminar conducted by the Department of Energy, Mines and Resources, and resulted in publication of Forecasting the Demand For Water, edited by Sewell and Bower.[2] This seminar pushed out the theoretical frontier on water demand forecasting, and much of the more recent effort has been devoted to filling in behind this frontier. For instance, a subsequent model developed by federal researchers[3] combined the influences of economic activity, technological advance and public policy in the determination of industrial water demand. Preliminary work has also been carried out using the input-output model as a basis for simulating water demand

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in all types of Canadian industry.[1] A 1979 study of consumptive water uses in the Canadian portion of the Great Lakes demonstrated that industrial water consumption would increase from three to five times present values by year 2000, depending upon the assumptions used in forecasting.[2] This study constituted one of the first attempts to examine regional consumptive water uses in Canada.

The Regional Context

Water management in Canada is approached at a federal level on the basis of five distinct geo-political regions. From east to west these regions are: Atlantic, Quebec, Ontario, Prairie and British Columbia. The Northern Territories are considered formally with the latter two regions, but for present purposes can be omitted as few industrial water demands originate in these areas. Being a country composed of distinct regions poses the interesting issue of breaking national data, especially forecasts, down into appropriate regional units. At a lower level, this problem can be extended to the regional-subregional interface.

Canadian water managers, as have most water resources practioners throughout the world, base their work within the context of river basins. The appeal of the river basin as a spatial organizing context is an appealing one from a physical point of view. A river basin forms a hydrologic unity such that whatever happens in the upstream area is certain to affect the downstream area to a greater or lesser degree. Also, river basin systems are physically independent of each other. Thus one river basin can be studied by itself, with a minimum of physical influence from surrounding basins. Each of these factors have contributed to the river basin being selected as a preferred unit of study within the water resource profession.

Yet from other points of view, which are also valid in a water management context, the river basin is a far from logical spatial unit, and may pose important problems. Since this paper deals with water demand forecasting it will be useful to illustrate this point by drawing upon a forecasting problem.

Socio-economic forecasts (e.g. population, economic activity, etc.) are vital parts of water demand forecasts. For example, one of the key determinants of industrial water demands is the volume of economic activity, however measured. In general, forecasting these variables is more accurate at

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[1]Canada, Department of the Environment, Inland Waters Directorate, "A National Water Demand Forecasting Model", by D.M. Tate, internal working paper, 1978.

[2]Canada, Department of the Environment, Inland Waters Directorate, Consumptive Water Use in the Canadian Section of the Great Lakes Basin, 1975-2035 Ottawa-Hull, 1979.

the national, or aggregate, level, since errors tend to be self compensating and because more data are available at this level. One key to successful water demand forecasting, therefore, is the ability to step down forecasts from the national to the regional and ultimately subregional levels. In Canada, the first level of regionalization is to the major geo-political area, as noted above. This regionalization process then proceeds to the provincial, economic region and economic subregion levels. Note that there is no place in this scheme for a river basin unit. The economic region construct is used in this stepping down process because the economic region is based upon a relatively homogeneous economic base, thus forming a convenient unit for forecasting. A river basin, in contrast, may transcend several economic areas. Thus, forecasting on a river basin basis alone will not produce the most accurate results possible. Rather, the approach must be based upon forecasting socio-economic variables at the economic region level first, and later upon stepping down these forecasts to the river basin level.

In Canada, a number of pieces of research are currently being carried out on this problem. The most extensive to date is a regional economic base study conducted by Environment Canada and several provincial agencies for the Prairie Provinces Water Demand study.[1] The regional economic base investigations took the approach outlined in the last paragraph, whereby the basin regionalization was the last in a multi-stage process of stepping down regional and provincial socio-economic data. Another piece of research is examining the stepping down process itself to determine which of the many models available[2] represents the best means of achieving accurately disaggregated data. A third research thrust is directed at using a recently developed regional input-output model in the water demand forecasting process.

Industrial Water Use

Surveys of industrial water use in Canada have been conducted for 1972 and 1976, with a further survey planned for 1981. According to the 1976 survey, total water withdrawal for manufacturing was 8,674 billion litres per year (Table 1). This represented an increase of just under 3% per year from 7,728 bly in 1972. The order of industries in terms of their water intake was unchanged from 1972, with the paper and allied group being first, and accounting for 36% of the total, followed by primary metals (24%) and chemical and chemical products (17%). The aggregate use rate for all manufacturing sectors was 2.3, which means that gross water use in manufacturing for 1976 was 20,043 bly. This use rate was unchanged from 1972. The amount of water consumed in manufacturing rose substantially over the 1972-1976 period, from

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[1]Canada, Department of the Environment, Inland Waters Directorate, Regional Economic Base Study for the Saskatchewan-Nelson River Basin, publication forthcoming, 1981

[2]Tate, D.M., Regional Economic Forecasts: An Evaluation of the Shift-Share Approach publication forthcoming, 1981

Table 1 Use Rates and Consumption Rates by Industry

Industry Group	Number Of Respondents		Use Rate		Cosumption Rate(%)	
	1972	1976	1972	1976	1972	1976
Food and Beverage	1,469	2,123	1.4	1.452	5.3	8.7
Rubber and Plastic Products	242	359	1.3	2.355	1.0	9.1
Textile Products	174	414	1.3	1.745	3.4	5.3
Wood Products	148	1,079	1.2	1.477	3.2	2.6
Paper and Allied Products	375	461	3.1	2.832	3.8	5.5
Primary Metal Products	201	238	1.8	1.944	2.7	3.7
Transportation Equipment	204	476	1.5	2.138	3.9	0.2
Non-Metallic Mineral Products	330	641	1.8	2.604	5.1	16.5
Petroleum and Coal Products	47	85	2.1	2.653	5.1	5.8
Chemical and Chemical Products	380	656	2.2	2.059	6.5	7.2
Total of Ten (10) other Groups	N.A.		N.A.		N.A.	
CANADA AVERAGE	4,437	6,571	2.3	2.312	4.2	5.3

Notes: $\text{Use Rate} = \dfrac{\text{Total Gross Water Use}}{\text{Total Water Intake}}$ $\quad$ $\text{Consumption Rate} = \dfrac{\text{Total Water Consumption}}{\text{Total Water Intake}} \times 100\%$

4.2% of total intake to 5.3%. In absolute terms, this represents an increase over the 4 years from 327 bly to 455 bly. The total discharge by manufacturers was 8,196 bly in 1976, up from 7,415 bly in 1972.

The pattern of use rates and consumption rates in the 2 survey years is shown in Table 2. In all cases but one, the use rate rose, suggesting a trend toward recirculating systems. However, the one fall in the use rate occurred in the paper and allied sector, the largest water user. This fall or decrease which cannot yet be explained, was sufficient to offset rises in the use rate in all other sectors. The amount of water consumed as a percentage of total water withdrawal (i.e. the consumption rate) also rose in all sectors but one, the transportation equipment sector, where the percentage fell dramatically from 3.9% in 1972 to 0.2% in 1976. Again, we have no satisfactory explanation for this decline, as the 1976 results have only recently become available.

Water withdrawal for mineral extraction in 1976 (Table 3) totalled 636 bly, excluding water use for deep well injection the petroleum and gas recovery process. In 1972, the latter use accounted for 66% of total withdrawal in the mineral sector. If this percentage still held true in 1976, total water withdrawal in 1976 would have been 1,055 bly. Assuming that water use for deep well injection was thus 418 bly, the gross use in this sector totalled 2,828 bly for a use rate of 2.7, slightly higher than that for manufacturing. Consumptive use totalled 496 bly (i.e. all of the deep well injection water plus 77 bly for all other mining sectors). Discharge from the mines totalled 559 bly in 1976. Thus the aggregate consumptive use rate was 47% (i.e. of total withdrawal), but is biased upward because all of the deep well water is counted as consumption. Without the latter's inclusion, the consumption rate for the sector was 12%, much higher than the similar rate for manufacturing, because of the extensive use of tailings ponds to entrap mine wastes.

On the basis of the foregoing paragraphs, industrial water withdrawal totalled just under 9,744 bly in 1976. To this must be added 54,000 bly for thermal power generation and 8,000 bly for agriculture. In mining and manufacturing, gross water use totalled just over 5,000 bly with consumption at 950 bly, over half of which water used for deep well injection. This figure is dwarfed by consumption in agriculture which totalled about 4,000 bly in 1976.

Industrial Water Demand Forecasting

The regional nature of Canada was highlighted earlier in this paper. The implication for resource management of this regional nature is that major studies are usually carried out at the regional or subregional level. This is the case in water demand forecasting, where the concept of national water demands must be developed from regional studies. This orientation of water demand studies recognizes and uses the fact outlined earlier that many of the socio-economic data series used must initially be stepped down from the national level.

Table 2 Water Use in the Manufacturing Industry, by Major Industrial Groups

NATIONAL Data (Billions of Liters per Year)

	WATER INTAKE				NUMBER OF ESTABL RECYCLING WATER	GROSS WATER USE (VOLUME)	WATER DISCHARGED (VOLUME)	
	NUMBER OF ESTABL	VOLUME TOTAL	FRESH	BRACKISH			TOTAL DISCHARGED	TREATED PRIOR TO DISCHARGE
TOTAL: ALL INDUSTRIES	6,571	8,672.718	8,323.571	349.146	1080	2,0043.823	8,216.227	4,243.827
10 FOOD & BEVERAGE INDUSTRIES	2,123	358.811	307.373	51.438	281	520.635	327.794	215.044
16 RUBBER & PLASTIC PRODUCTS INDUSTRIES	359	59.471	58.507	0.964	74	139.999	54.097	4.273
17 LEATHER INDUSTRIES	1	0.214	0.214	0.000	0	0.214	0.214	0.214
18 TEXTILE INDUSTRIES	414	138.717	138.717	0.000	43	242.42	131.461	27.867
25 WOOD INDUSTRIES	1,079	331.04	271.324	59.716	62	488.827	322.698	226.218
26 FURNITURE & FIXTURE INDUSTRIES	2	0.014	0.014	0.000	0	0.014	0.014	0.000
27 PAPER & ALLIED INDUSTRIES	461	3,132.171	5,121.361	10.81	152	8,867.787	2,961.805	1,769.653
28 PRINTING, PUBLISHING & ALLIED INDUSTRIES	6	0.164	0.164	0.000	2	8.310	0.159	0.000
29 PRIMARY METAL INDUSTRIES	238	2,094.329	1,998.626	95.702	94	4,071.0433	2,017.510	991.719
30 METAL FABRICATING INDUSTRIES	22	8.406	8.406	0.000	12	11.215	8.283	2.469
31 MACHINERY INDUSTRIES (EXCEPT ELECTRICAL MACHINERY)	5	0.246	0.246	0.000	2	0.264	0.246	0.000
32 TRANSPORTATION EQUIPMENT INDUSTRY	476	375.709	375.677	0.032	71	802.937	373.495	45.546
33 ELECTRICAL PRODUCTS INDUSTRIES	3	0.255	0.255	0.000	1	0.255	0.25	0.041
35 NON-METALLIC MINERAL INDUSTRY	641	94.711	93.175	1.536	79	246.548	79.123	45.833
36 PETROLEUM & COAL PRODUCTS INDUSTRIES	85	615.751	535.603	62.148	38	1,633.01	580.406	492.286
37 CHEMICAL & CHEMICAL PRODUCTS INDUSTRIES	656	1,462.730	1395.927	66.804	169	3,010.370	1,358.663	422.687

Table 3

Water Use in the Mining Industry, by Major Industrial Groups
National Data (Billions of Liters per Year)

	WATER INTAKE				NUMBER OF ESTABL RECYCLING WATER	GROSS WATER USE (VOLUME)	WATER DISCHARGED (VOLUME)	
	NUMBER OF ESTABL	VOLUME TOTAL	VOLUME FRESH	VOLUME BRACKISH			TOTAL DISCHARGED	TREATED PRIOR TO DISCHARGE
TOTAL: ALL INDUSTRIES	482	637.249	617.647	19.602	143	2,410.480	561.026	324.694
05 METAL MINES	125	541.542	537.174	4.369	80	1,977.269	483.044	309.046
06 MINERAL FUELS	26	8.947	8.919	0.027	6	38.55	7.019	0.882
07 NON-METAL MINES (EXCEPT COAL MINES)	106	51.315	38.887	12.429	21	178.444	46.337	13.856
08 QUARRIES & SAND PITS	225	35.445	32.668	2.778	36	216.221	24.630	0.905

Figure 1 illustrates the general setting of industrial demand forecasting. Industry is one of several sectors for which forecasting is carried out. The industrial sector receives relevant socio-economic data from the more general regional level models. The socio-economic information is then combined with industry-specific information in a model of industrial water use (Figure 2). The industrial model combines economic, technological and policy factors to simulate industrial water demands. This model has been described in detail in a previsouly published report.[1] This forecasting framework consists of several modules, each one of which can deal with a specific industry under study.

The overall philosophy of water demand forecasting in Canada embraces the alternative futures concept. The future cannot be foretold with anything like complete accuracy, and the best way of coping with this situation is for forecasting exercises to consider formally two or more scenarios of future development. The simulation framework of industrial water demand forecasting in Canada allows sufficient flexibility for a wide range of alternative futures to be considered. This approach was used recently in a study of consumptive water use in the Canadian portion of the Great Lakes basin.[2] Although time and manpower did not permit full consideration of all variables deemed to be important in industrial water demand forecasting, it was found that the model produced forecasts which were acceptable for the planning exercise of which the project was a part. Currently, work is underway to incorporate an effective method of stepping down national economic forecasts in a manner suitable for inclusion in the model.

Concluding Remarks

The regional nature of Canada's economy means that most of the work on water demand forecasting is carried out at the regional level, and therefore that methods of disaggregating social and economic data from the national to the regional and subregional levels are required. Research is currently progressing on this front. Also the simulation modelling approach to forecasting is under development for the drier Western interior portions of the country. Research is directed here at developing proper operational definitions for the variables of the simulation model, and at defining the relationships between them.

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[1] Industrial Water Demand Forecasting, op. cit.

[2] Consumptive Water Use in the Canadian Section of the Great Lakes Basin, op. cit.

FIGURE 1 MANUFACTURING AND MINING WATER USE AND DEMAND FORECASTING MODEL

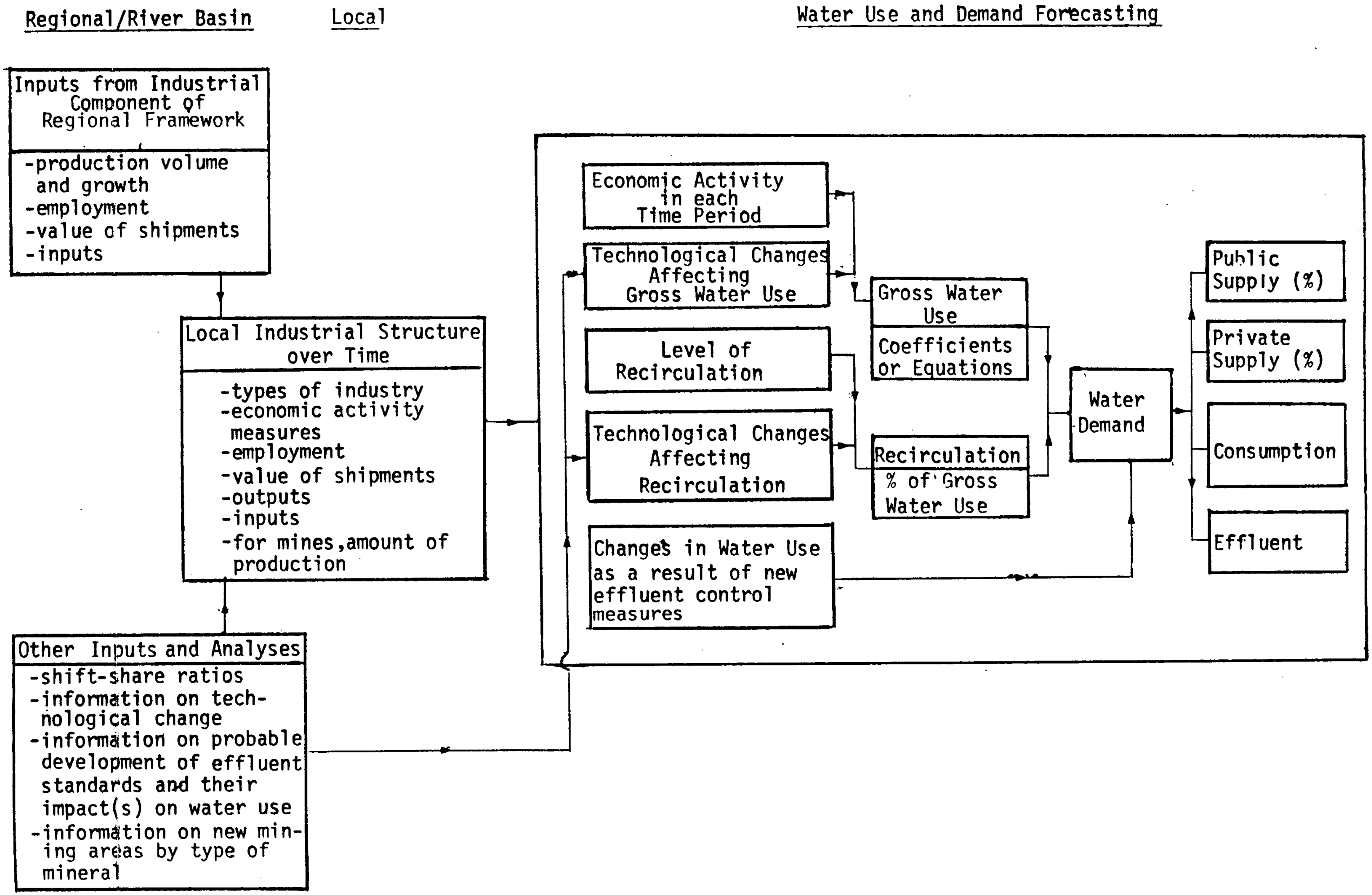

FIGURE 2 AN AGGREGATE WATER USE AND DEMAND FORECASTING FRAMWORK