Collaborative Paper

DRINKING AND INDUSTRIAL WATER
DEMANDS IN THE NETHERLANDS

J. Mülschlegel

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International Institute for Applied Systems Analysis
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PREFACE

Water resources systems have been an important part of resources and environment related research at IIASA since its inception. As demands for water increase relative to supply, the intensity and efficiency of water resources 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 resources development alternatives aided by application of mathematical modeling techniques, to generate inputs for planning, design and operational decisions.

In the years of 1976 and 1977, IIASA initiated a concentrated research effort on the modeling and forecasting of water demands. Our interest in water demands derived itself from the generally accepted realization that these fundamental aspects of water resources management have not been given due consideration in the past.

This paper, the ninth in the IIASA water demand series, reports on the analysis of drinking and industrial water demands carried out recently in the Netherlands for the preparation of a master plan concerning water resources management in that country. The preliminary version of the paper was drafted by J. Mülschlegel during his two visits to IIASA in 1977 and 1978. The paper is one of several invited contributions to IIASA's "Survey on Methods for Estimating Water Demands and Wastewater Discharges".

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ABSTRACT

Structural plans have been drawn up in the Netherlands for the various sectors of government administration. These long-term plans, by their very nature and extent, are only of a provisional character. Within this framework a master plan on how to meet future drinking and industrial water demands has been prepared by the National Institute for Water Supply.

Until recent years, various types of trend extrapolation were used for all forecasts of water demand. At this moment a Component Method of Forecasting is in practice. Recent research programs have resulted in detailed data on industrial, commercial, public and household water uses. Several factors which determine water use are discussed in this paper.

Table of contents:

1. Introduction

In the Netherlands Structural Plans are drawn up for the various sectors of government administration, the long-term plans (covering approximately 30 years) are of the nature and extent of feasible and necessary provisions. This method of planning dates from 1972 when the Minister of Housing and Town and Country planning (physical planning) asked an interministerial commission to prepare a master-plan for the town and country planning of the future. Within this framework it will be necessary for several sections of the government to prepare master-plans for the subjects coming under their competence in close cooperation with the plans concerned in other sectors. The combined sectional plans create the possibility for a well-founded government policy in economic, social and environmental aspects and for the decision as to how town and country planning has to be developed in order to ensure a minimum of conflicts.
The general ideas underlying this planning are:

- planning for periods of 3 to 5 years is insufficient for the execution of major projects (seaports, powerstations, reservoirs and water supply infiltration projects);
- it is desirable to have in early stage a rough idea of the physical and financial feasibility of schemes; in this way timely consideration of alternatives is possible, for example after conflict with other sectors;
- early comparision of the proposes policies of the sectors and the overall policy. For example the sum of demands made on the space of raw materials (i.e. ground and surface water) available may easily place an unacceptable burden on the environment;
- early information on government policy with regard to the large infrastructural projects wil provide major points of departure that will enable local authorities to decide on their course of action.

In addition to sectorplanning also factorplanning is necessary, in this case special total water use (quantity an quality problem) of the several sectors.

The planning of water-management in the Netherlands takes place at various levels. Regional level plans are drawn up in units responsible for water-management (water-boards, provinces) while similar plans are also prepared in various sectors (supplies of drinking water and water for industrial use, agriculture and shipping). The central authorities are confronted with the task of combining the regional and sectoral plans into an integrated plan for water-management.
In connection with the planning of integral water-management in the Netherlands a joint study relating to the development of a systems model (Policy Analysis of Water-management in the Netherlands - PAWN) is now being carried out by the Ministry of Transport and Public Works.

2. Organisation of the planning of drinking and industrial water supply.

The master plan for the future water supply has been prepared by the Rijksinstituut voor Drinkwatervoorziening (National Institute for Water Supply/Ministry of Health and Environment).
This plan deals successively with the following subjects:

- water problems in general;
- the future water demand;
- the available water resources;
- the desirable government policy;
- the works to be constructed;
- the administrative procedures which necessarily precede the execution of works.

Of predominant importance is the government policy indicated in this plan with regard to the objectives of water supply. These are defined in such a way that it is clear what interests are involved in water supply planning. A further analysis of the objectives leads to certain conclusions, the main ones relating to water management, town and country planning, research activities, the economy and the environment. These conclusions, as a basis for government policy, will have consequences for the practice of water supply management as well as for physical planning. The agreed policy implies the kind and size of the technical works which must be constructed. In order to guarantee the construction of these works a special legel basis will be created for more detailed plans.
The master plan must be revised periodically, in principle, every five years. The date mentioned in the title of the master plan indicates that the policy it lays down is based on the view existing in that particular year.

Besides the long-term plan (master plan) there is also a medium-term plan. This is a ten-year plan prepared by the Vereniging van Exploitanten van Waterleidingbedrijven in Nederland (the Netherlands Waterworks Association), which enters into details and has to fit into the framework of the long-term planning of the government. The ten-year plan gives a detailed survey of the existing waterworks, as well as the works that have to be established to secure a reliable water supply for the coming ten years. This plan must be revised every two years.

As has been seen from the above, the water supply for the population and industry and for other sectors will be a part of the assessment of integral and regional interests. This, however, does not alter the fact that the sectoral water supply should equally be seen as a total system because of the mutual relationship between the projects functioning in this system and the supra regional aspects which are often connected with this. Taking the objective as the ensurance of the drinking water and industrial water supply, optimum solutions will have to be sought by means of a systems approach, though these need not necessarily also be optimum in a regional or integral sense. The objective of ensuring the public drinking water supply in the Netherlands involves the safe, uninterrupted delivery of sufficient water at sufficient pressure and of good and constant quality in a responsible way in terms of the national economy and the community, in order to provide for the needs of the population and industry in such a way that other interests are harmed as little as possible and so that these activities fit in harmoniously with the desired physical structure, regard being had to the basic starting points of environmental hygiene and the general ecological conditions.

A systems model is at present being developed to enable a water supply system based on the above objective to be designed, in which respect we have opted for a set up consisting of separate sub-models. In addition, a distinction has been made between systems models for long-term, medium-term and short-term planning which, incidentally, should interact with each other. With regard to the long-term plan thought is being given to a financial and economic optimisation of alternative water supply systems, in which respect the effects must be indicated to other sectors, quantified if possible. This is based on estimates of water requirements obtained by comparing a domestic water consumption sub-model with the available quantities of groundwater and surface water derived from sub-models (see figure 2.1.).
For the purpose of financial and economic optimisation, a sub-model has been developed which permits an optimum choice to be made from water recovery projects and the associated network of main supply pipelines, by minimising the costs (lit. 2). Promising alternatives can be selected which can be worked out in further detail in the context of the medium-term planning. A more detailed optimisation of possible alternatives should take place, having due regard to all the relevant aspects. For those purposes consideration is being given to using multi-objective optimisation techniques. At present The Surrogate Worth Trade-Off method is being investigated with regard to its possible applications.

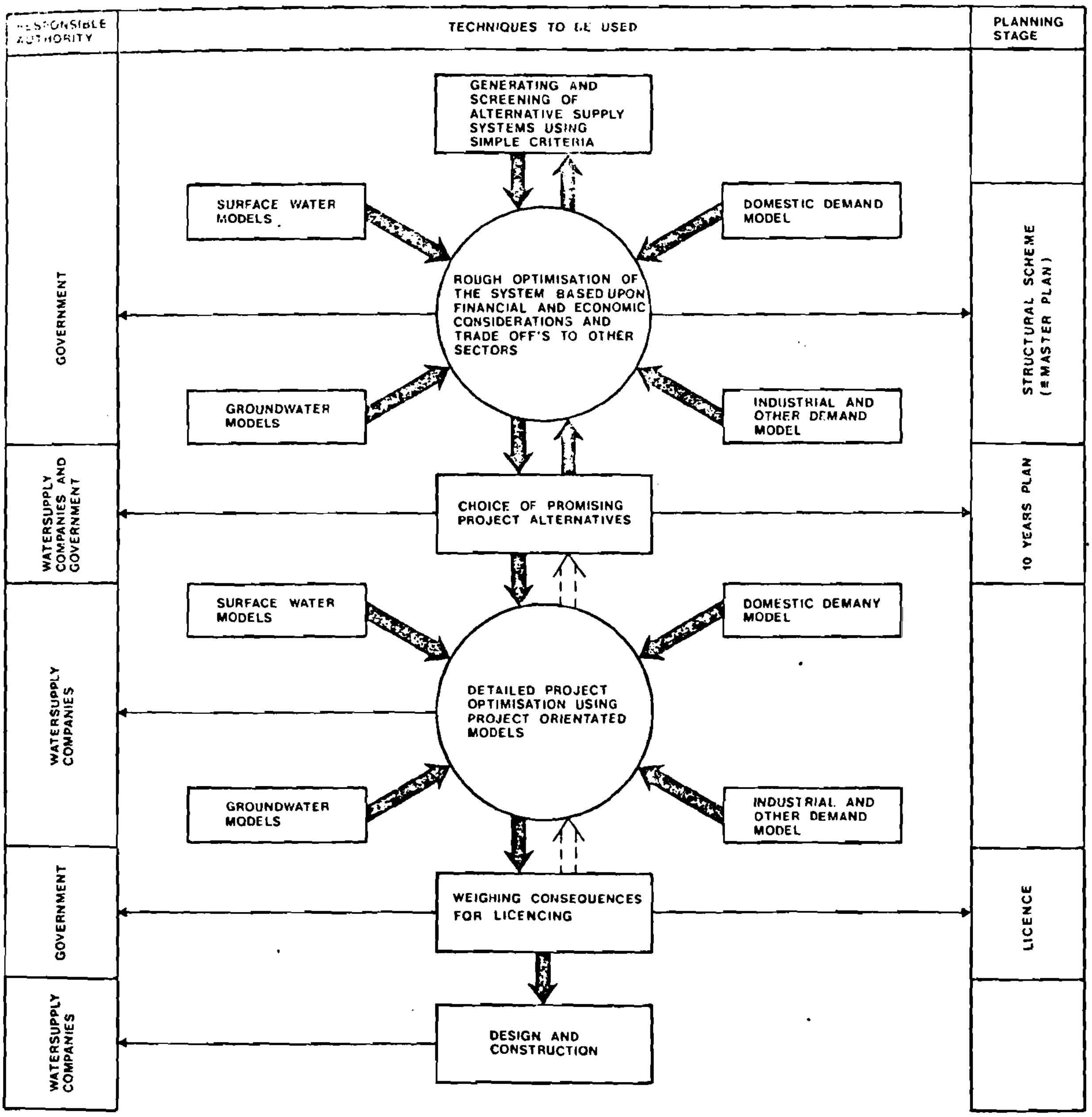


FIGURE 2.1.
STRUCTUAL SYSTEM MODEL FOR DRINKING WATER AND INDUSTRIAL WATER SUPPLY

3. Drinking and industrial water demand.

A study of water consumption is in progress in the Netherlands for the purpose of collecting basis knowledge for the forecasting of water requirements, to assist the planning of domestic and industrial water supplies, especially fit in with the masterplan. In this chapter a summary of the analyse of the historical demand is given.

3.1. Introduction.

In the Netherlands several categories of water use are distinguished based on the kind of consumer and supply:

A. Supply by public water company
   1. demand of households;
   2. industrial demand;
   3. demand of commercial, public and agricultural groups and recreational facilities;
   4. other demands: - leakage losses
      - demand of the water-works.

B. Self-supply
   1. demand of households;
   2. industrial demand;
   3. demand of commercial, public and agricultural groups and recreational facilities.

We have to note that in the Netherlands the use of surface water for cooling purposes is not included in the forecasting for the master plan. Water withdrawn for agriculture from ground and surface water sources is also not included in the master plan.

Figure 3.1. shows a stream flow diagram of the total water consumption in the years 1972 and 1976.

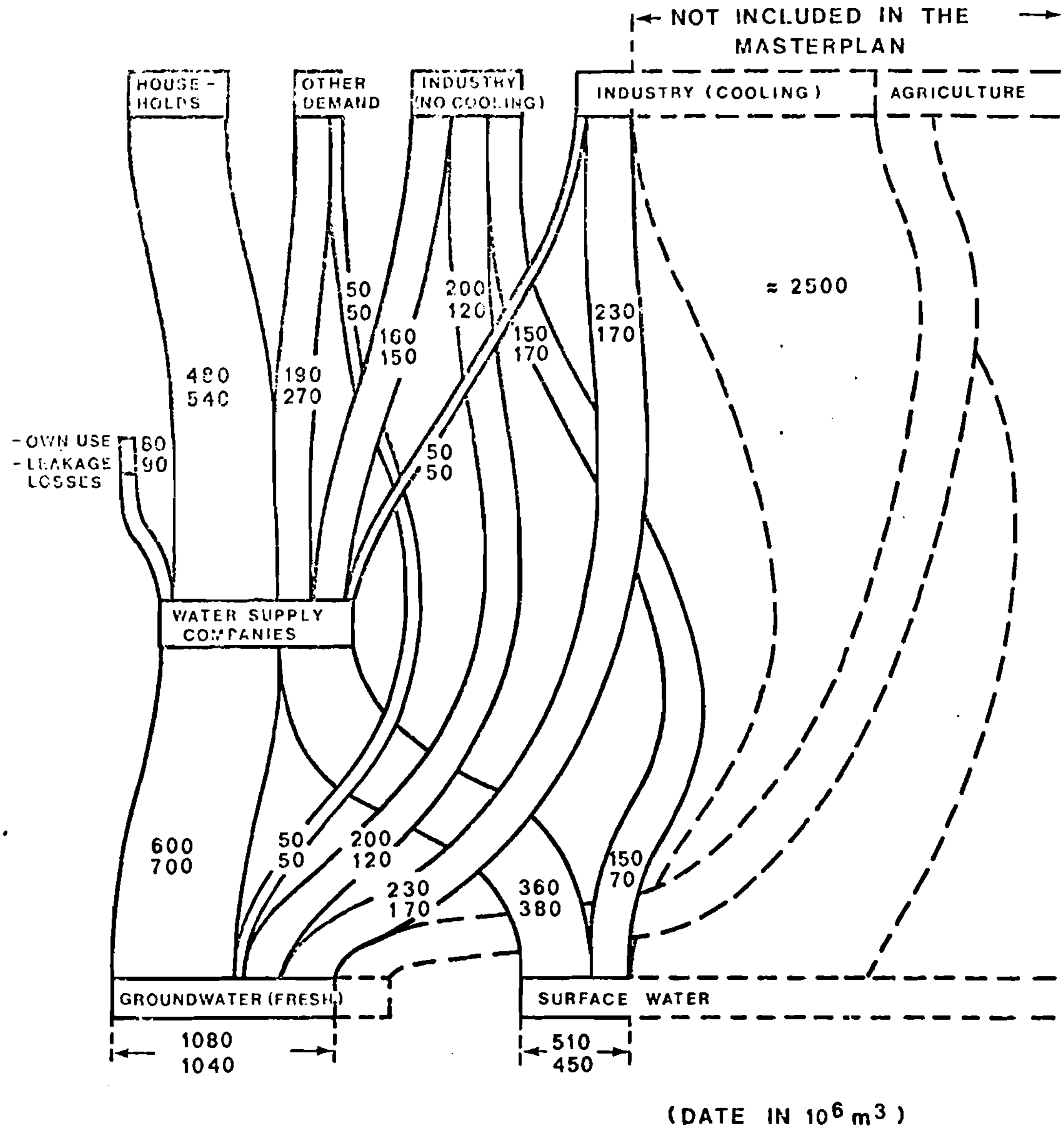


FIGURE 3.1.
DRINKING, INDUSTRIAL AND AGRICULTURAL WATER SUPPLY IN 1972 AND 1976

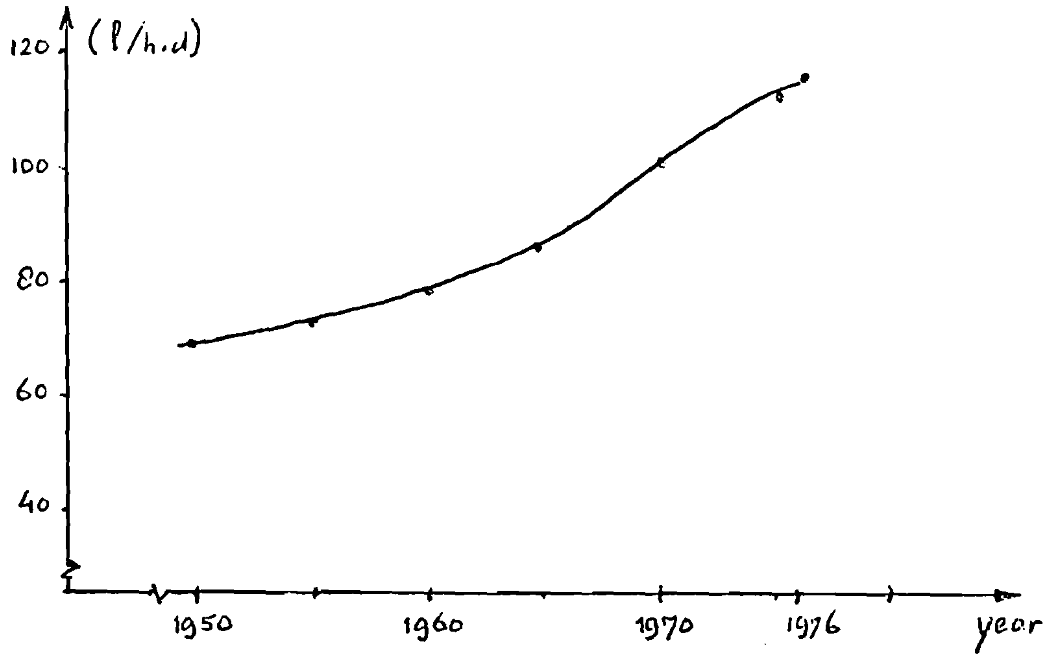
3.2. Domestic water demand (A1 + B1).

At present fewer than one per cent of the dwellings are not connected to the public water supply (= B1).
These dwellings are disregarded here.

The generally accepted definition of domestic water consumption is:
Water consumption is the consumption entailed by activities both inside and outside a dwelling that is intended for permanent occupation.

Some idea of total domestic water consumption is provided by figure 3.2.1., which shows the trend of per capita consumption over the period from 1950 to 1976, based on delivery within this category by the public water supply. It should be noted that these data are not always based on direct measurement of water consumption. Consequently, the consumption figure also includes shops and small industrial establishments.

Fig. 3.2.1.: Average per capita consumption (small users).



The activities in which water is used in a household may be classified in various ways (we have opted for the third classification):
a.1. personal consumption;
a.2. consumption related to the dwelling;
b.1. consumption in the dwelling;
b.2. consumption outside the dwelling;
c.1. personal hygiene of the members of a household: washing, brushing teeth, using the lavatory, etc.;
c.2. laundering: washing, rinsing, pressing, moistening, etc.;
c.3. preparation of meals: cleaning the ingredients, preparing food, dishwashing, making coffee and tea, etc.;
c.4. cleaning the home: cleaning rooms, kitchen, etc., scrubbing, mopping up, cleaning windows etc.;
c.5. other activities: watering the garden, washing the car, watering plants, tending pets, etc.

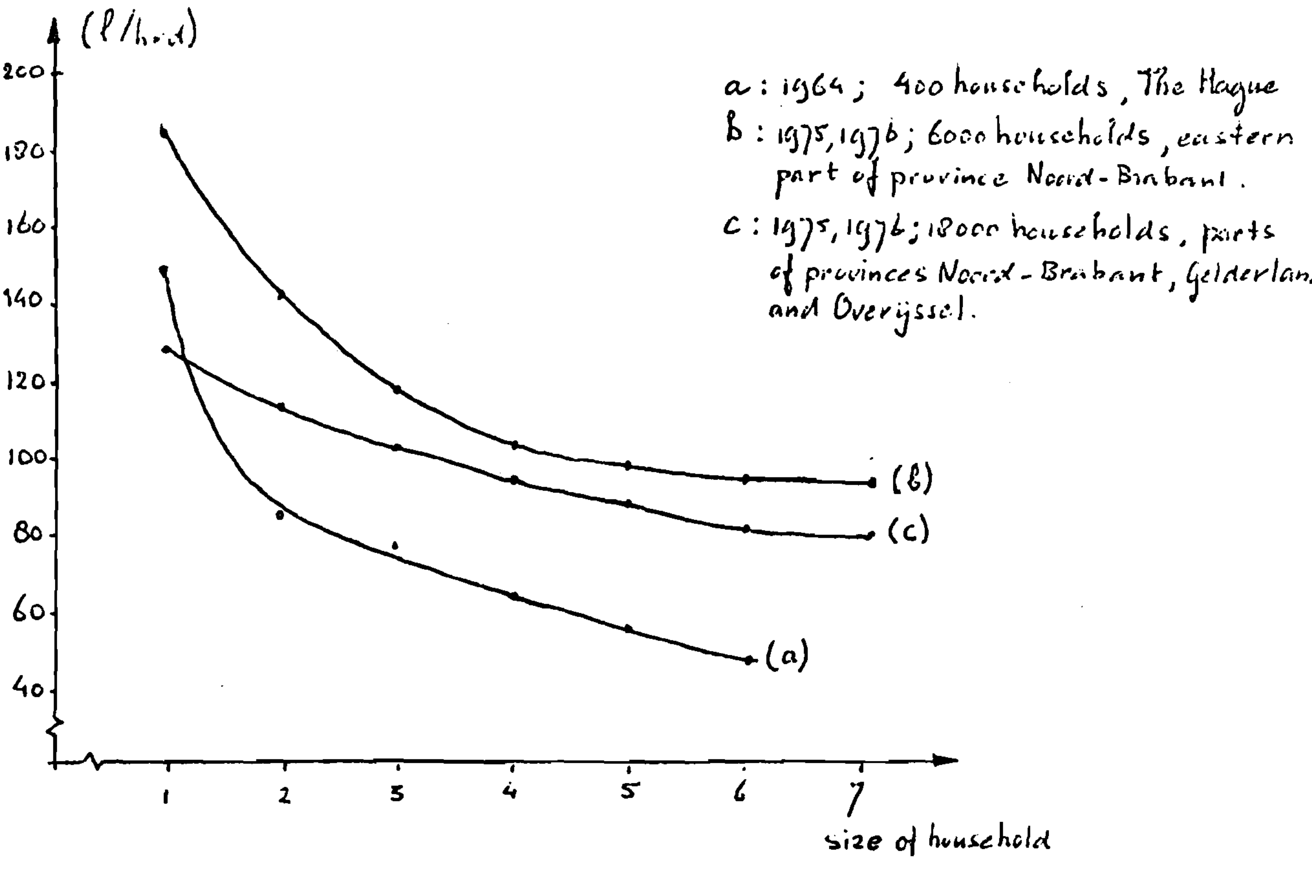
Clearly, not all these activities consume the same quantities of water. There are, for instance, differences in the degree in which they occur, both in terms of presence and frequency, and in hot water consumption of each operation. The combination of presence, frequency and consumption per operation indicates what part of total consumption is attributable to a particular operation in this category. This aspect will be reverted to subsequently.

The factors considered to be of influence on domestic water consumption are numerous and may relate to presence, frequency and consumption of the various operations. The effects of these factors may vary both regionally and locally. As far as the individual household is concerned, the effects of the following factors are taken into account.

- First, the size of the household. A large household will obviously use more water than a small one, since personal consumption will increase in proportion to the number of persons. With depletion of the family, personal consumption will rise as a result of the larger share taken by non-personal consumption. In this country family depletion has been occurring at a fairly high rate in recent years; from about 4 persons in 1960 to 3.2 persons in 1976.

  A limited survey showed that total per capita consumption is not proportionate to the number of persons in the home (see fig. 3.2.2.).

fig. 3.2.2.: Average per capita consumption in relation to the number of occupants of a home (reference years 1975 and 1976).



- The effect of the composition of the household stems from the fact that children, for example, have and/or entail different needs from adults.
  In this context the family phase may be considered a major influence. The cycle completed by a family is usually divided into a number of phases:
  1. the initial phase - newly married, husband and wife both working in many cases; formation of the household routine;
  2. the growing family - children arrive, the wife often stops working;
  3. the completed family - the children start earning;
  4. the diminishing family - the children leave home; only the married couple, or one of them, is left.

  Each phase is attended by its own pattern of living and corresponding water consumption (governed e.g. by degree of presence, children's ages, income).

- Education, occupation and income are taken as indications of social status, social class and mode of living of the household. In a large number of cases there is a clear relation between these three factors. In the higher income brackets certain types of domestic appliances and comfortably appointed houses are encountered more frequently. However, it is not only a higher level of affluence that leads to increased ownership of consumer durables. The position is also influenced by the wife being gainfully employed.
  The level of education seems to have little effect on opinion forming as regards the desirability of a particular consumption pattern.
  Occupation can also affect the water consumption of a household for personal hygiene and washing, if one or more of its members' occupation involves "dirty work".

- The following are a number of aspects whose influence on water consumption is difficult to assess:
  - the household's social activities - scale and frequency of entertaining and visiting;
  - leisure activities;
  - status symbols - these often lead to a particular, wasteful way of living.

  This latter aspect involves a "psychological factor" which has an indirect effect on water consumption through its influence on all manner of decisions concerning mode of life, purchase, use, association etc. They are the standards and habits of the household, the living standard aspired to. For instance, the number of times a day dishwashing is done, the size of the washing up and, with it, the water consumption, will not only depend on the number of persons, but also on the way the meals are served (saucepans or dishes on the table, whether or not a clean plate and clean cutlery are used for each course, etc.), the method of washing up (pre and post rinsing) etc. will affect water consumption.

- Whether or not price is a factor influencing consumption can only be ascertained in those cases where the cost is visible. The effect of price changes on consumption, i.e. price sensitivity depends not only on the extent of the increase/decrease in price, but also on the structure of the consumer price and the use the water is put to. Initially, an increase in the price of water will not greatly affect the consumption of water in the house, but it will have more effect on the outdoor use of water, for instance, for watering the garden and washing the car. The limited price elasticity is due to a number

of factors:
- in the household, tap-water is largely irreplacable (hygiene, preparation of food);
- expenditure on water represents only a very small part of the family budget (about 0.5 per cent);
- automatic (giro) remittance of water charges which greatly reduces visual impact;
- in many cases the water rates are included in the rent.

- The extent to which individual measurement affects water consumption is being analysed in current investigations. Interim results of these investigations and regular comparison between average water consumption in supply areas with metered and non-metered dwellings warrants the cautious conclusion that installation of an individual meter generally leads to a (temporary) reduction in consumption and is partly responsible for average consumption in metered homes being lower.

Before going into details of the present structure of domestic water consumption, a definition of what is meant by a household would seem appropriate.

The term "household" is used to describe any group of two or more persons who live together under conditions of domensticity and together run a communal household (i.e. sharing a living room, the cooking, meals, etc.). Distinctions are drawn between single-family, multi-family and non-family households. Although persons living alone are not included in this definition, they will - in order to simplify discussion - be referred to as single-person households.

In describing the structure of present-day domestic water consumption the afore mentioned division into 5 categories will be adhered to.

A - Personal hygiene

A substantial part of water consumption in the household is accounted for by toilet flushing and bodily care.
Besides the availability and technical characteristics of the sanitary equipment, it is essential to know the frequency with which certain operations and uses occur.

- There are various designs of w.c. cisterns. The tendency for some time now has been to install cisterns with somewhat reduced water consumption. Depending on the type of cistern, consumption will vary from 6 to 15 litres. Average consumption is 8 litres. The frequency of flushing is influenced by the fact that people are absent from their homes for part of the time (office, factory, school etc.). Average frequency is 4 times a day per person. Hence, specific consumption for toilet flushing is 32 l/h.d.
- Water consumption at the washbasin averages 3.5 l a time. A frequency of 10 times a week results in a consumption of 5 l/h.d. Total water consumption for showers and baths is determined in part by the availability of these facilities in the houses. It has here been taken as 68 per cent and 21 percent respectively. Average consumption per use of shower and bath is 60 and 120 l respectively. The frequency of use being 3.5 and 2.5 a week, this gives an average per capita consumption of 29 l a day. Total specific water consumption for bodily hygiene thus amounts to 34 l/h.d.

B - Laundering

It is necessary to distinguish between washing by machine and by hand. In this country the washing machine (automatic or otherwise) is a firmly established and indispensable appliance to be found in 90 per cent of households. In most of the remaining households the laundry is not done at home. In spite of the washing machine's high degree of penetration, manual washing is still practised, even in homes where there is a machine. An important development affecting water consumption is the increase in garments made of synthetic fabrics. Together with coloured articles, they account for one-third of the weight of the dry wash. By unit of weight more water is used for these kinds of articles than for white articles. The loading of the machine also plays a part, especially with coloured and woollen articles. The technical characteristics (make and type) of the machine also affect its water consumption. Consumption ranges from 85 to 180 litres a week, the average being 135 l. Frequency of use will depend on size of the family, family phase and behaviour pattern (e.g. views on cleanliness). With an average-sized family the frequency will be 4 washes a week. Where water consumption amounts to 2 l/h.d. for washing by hand, consumption in households with a washing machine will average 23 l/h.d. Total specific consumption for laundering is then 23 l/h.d.

C - Food preparation, dishwashing etc.
Divergent customs in the matter of preparing food result in a wide spread of water consumption per household. We have put the average at 3 l/h.d. Direct (tea, coffee, etc.) and indirect consumption of water is about 1 l/h.d. This consumption varies with taste.
In the Netherlands the dishwashing machine is still a comparative rarity, with a penetration of 8 per cent. Diswashing by hand is still general practice. There are different ways of manual dishwashing, resulting in a fairly wide variation in water consumption. Washing and rinsing in one or more bowls will use the least amount of water. If rinsing is done under running water there will be an appreciable increase, while washing and rinsing under running water means a multiplication of water consumption. For a manual dishwashing frequency of 3 times a day we have put average consumption at 11 l a time. When there is a dishwasher, the frequency of manual dishwashing drops to once a day, besides which consumption is then reduced to 10 l a time. Average water consumption of dishwashers is 40 l per operation. With a use frequency of 5 times a week this results in consumption of 12 l/h.d. in households with a dishwasher. Specific water consumption for washing up is then 11 l/h.d.

D - Water consumption for cleaning purposes in the house is slight and may be put at 1 l/h.d.

E - Like the consumption mentioned under D, water consumption in the course of other activities is relatively slight. The components are car washing, watering the garden, tending potted plants, etc. Although these consumption components are put at only 1 l/h.d., watering the lawn during the six summer months in residential areas with a relatively high number of large gardens can cause substantial peaks in consumption.

Table 3.2.3. shows the structure of present-day average domestic water consumption.

It should be noted that this is a national average, which may differ from regional or local consumption figures.

Table 3.2.3.

category	present-day consumption
. - using the lavatory	32 l/hxd
- personal hygiene of the members of a household	34 "
. laundering	23 "
. preparation of meals, dishwashing etc.	15 "
. cleaning the home	1 "
. other activities (a.o. washing the car and watering the garden)	1 "
total	106 l/hxd

With the population of the Netherlands numbering 13.7 million, total domestic water consumption over a period of one year, based on the data from table 3.2.3. is 530 x $10^6 m^3$. Since this volume applies to an average year, the figure may differ somewhat from the quantity delivered to households by the public water supply in an extreme year, especially on days with a high peak consumption.

3.3. Industrial water demand (A2 + B2)

For the purpose of this report, industry has been divided into industrial categories, branches and sub-branches. The most important of these in terms of water consumption are shown in table 3.3.1. together with their water consumption and corresponding production over a number of years.

Water production and re-use meet the demand of water in industry.

The supply of water for industry comprises:
- supply of tap-water, divided, where necessary, by quality into: non-purified or only partly purified water, drinking water and water purified beyond the standard for drinking water;
- private recovery of fresh ground water;
- private recovery of fresh surface water;
- private recovery of brackish or salt ground water;
- private recovery of brackish or salt surface water.

The first two sources are of importance for the Structural Diagram; the third only as far as this water is not used exclusively for cooling purposes.

Industrial water consumption can be subdivided, according to use, into water for:
- cooling;
- boiler feeding;
- processing purposes;
- sanitary use;
- other purposes, including flushing, washing, cleaning, fire extinguishing.

All these purposes set certain standards as regards the quality of the water. These standards vary widely by use and by industry. This is illustrated by the fact that, on the one hand, tap-water is used for cooling purposes, as on the other hand non-purified surface water suffices for some processing purposes.

Of total industrial consumption of about 550 million m^3 in 1976, some 200 million m^3 were provided by the public water supply. About 25 per cent of this was of a quality different from that of drinking water.

Industrial water consumption is influenced by numerous factors, many of which are inter-dependent. The most important of these are:
- scale of production;
- production capacity;
- number of employees;
- price of the water;
- quality of the water available;
- technology;
- mentality;
- government measures.

The weight of these factors differs by industry and type of use or supply.

Table 3.3.1.

industry	branches	in study	study completed
Food, drink and tobacco industry	o Slaughter houses and meat processing	x	x
	o Poultry o Dairy and milk products	x x	x .
	o Sugar o Fish processing plants o Flour, barley and rice mills	x - -	. - -
	o Fats and oil refining and processing	x	x
	o Vegetable and fruit processing	x	x
	o Bakeries, biscuit factories ect.	-	-
	o Cocoa, chocolate and sweets	-	-
	o Starch and starch derivatives		
	o Foodstuffs	-	-
	o Other food industry	-	-
	o Distilleries		
	o Breweries and molting houses	x	.
	o Soft drinks	-	-
	o Tobacco processing	-	-
Chemical industry		x	.
Petroleum industry		x	x
Paper industry		x	x
Metal processing and electrotechnical industry		x	.
Metallurgical industry		x	.
Textile industry		-	-

Closer analysis of these factors and their influence on water consumption will take several more years of research.

From research performed to date (see table 3.3.1.) in collaboration with industry, it has meanwhile been ascertained that in a large number of industries ther is a demonstrable relation between the scale of production and water consumption.
This had led to the introduction of the term "specific water consumption", which is defined as the quotient of water consumption and one or other factor which is a yardstick for the size of a plant. This factor may be the scale of production, the number of employees, the raw materials consumption, etc. There is evidence that this specific consumption changes with time. Moreover, within a particular industry fairly considerable deviations from the average may occur. This, alone, is an indication that besides the afore mentioned factor (production), other factors affect consumption.

The aim of research, so far, has been to determine the trend of specific consumption in the various industries. However, since water consumption is not in principle a function of time this research implies assumpions concerning the trend of those factors that are conditioned by time. Although these cannot be determined quantitatively it is possible to say of a number of them whether they have been of influence and, if so, in a positive or a negative sense.
Among the most important of these are:

- introduction of the Pollution of Surface Waters Act in the period after 1970; although primarily aimed at combatting pollution, this government measure has considerably affected consumption:
  - . the dirt load had to be reduced; purification by industrial plants meant that less dirty water suitable for a number of uses became available, resulting in lower over-all water consumption;
  - . a levy was charged on the residual dirt load, and in many cases on the quantity of water as well. This considerably raised the cost of over-all water management, so that in a number of cases the alternative means of satisfying the demand - re-use - became financially interesting;
  - . the Pollution of Surface Waters Act and its discussion has focused increased attention on industrial water management, resulting in more rational consumption in many plants, this development probably commenced before 1970; because of this and the gradual introduction of rationalisation programmes in industry, the graph representing specific consumption in 1970 did not develop a pronounced turn (see fig. 3.3.2.).
- the introduction of the provincial ground-water regulations; besides compulsory registration, these also featured compulsory licensing; apart from the fact that in specific cases withdrawal is permitted only on a limited scale, if at all, these regulations have likewise drawn increasing attention to industrial water management;
- the very sharp rise in energy prices; among others things, this has led to better utilisation of the heat transmitted by water (cooling water, steam).

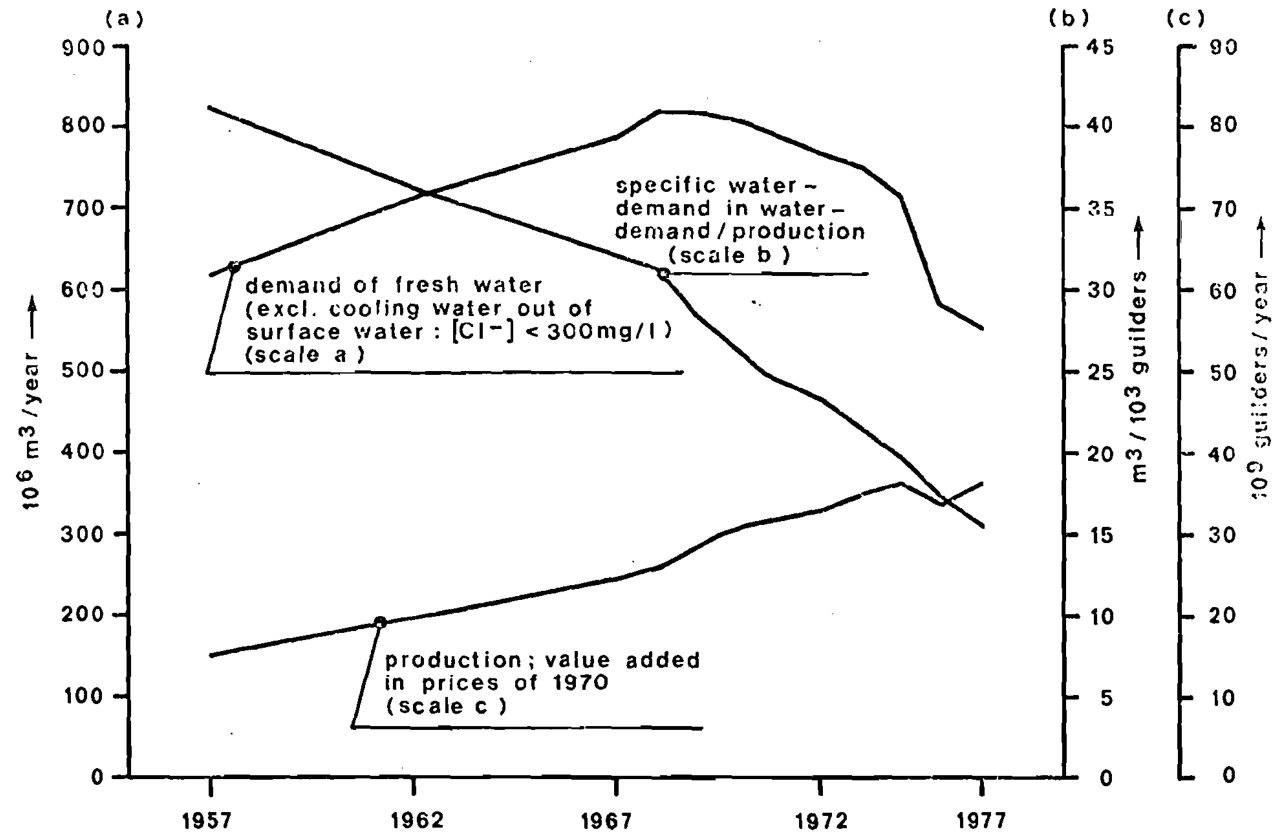


FIGURE 3.3.2.
AVERAGE SPECIFIC WATERDEMAND

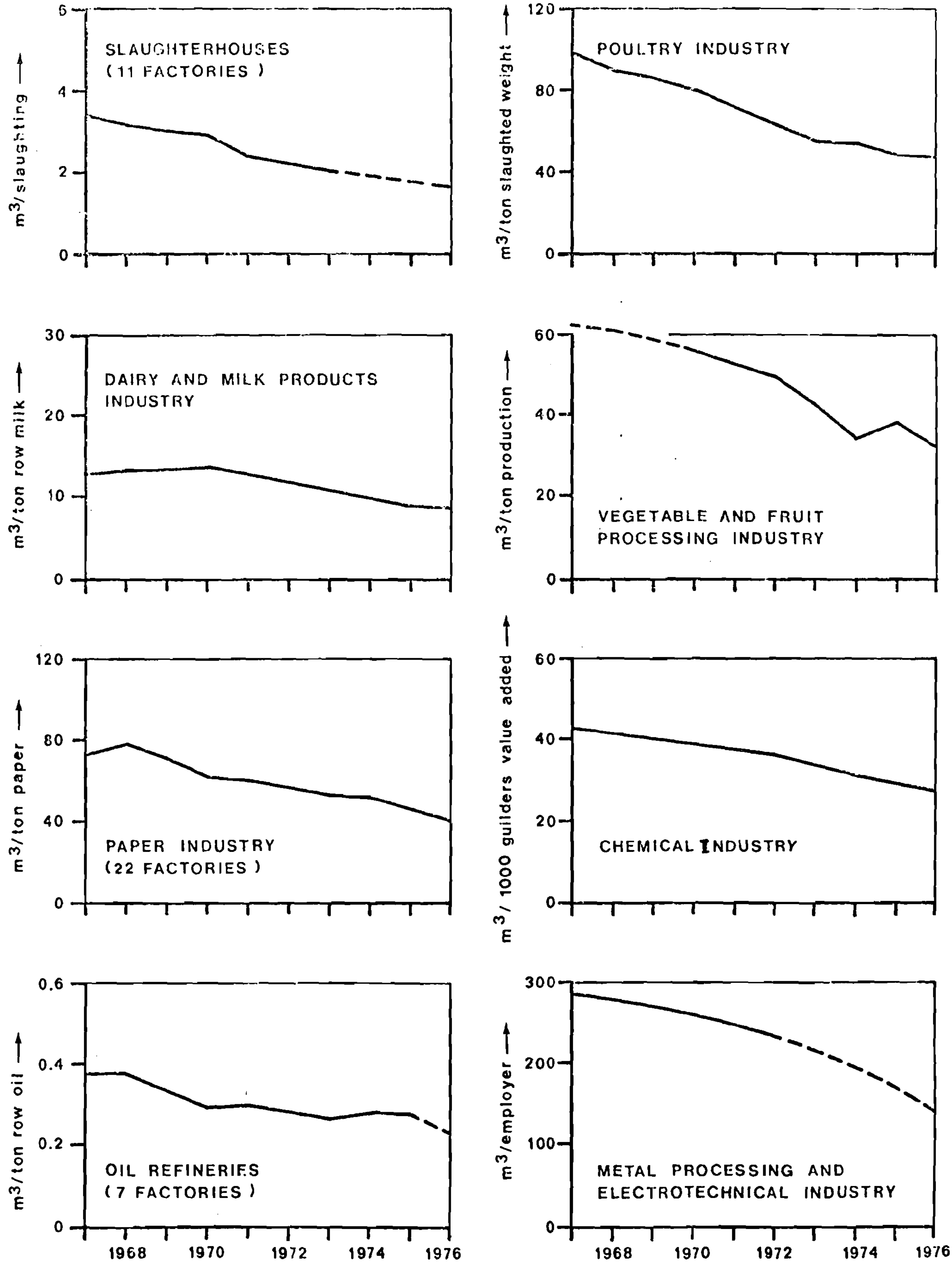


FIGURE 3.3 3.
SPECIFIC WATER CONSUMPTION PER BRANCH

- the sharp rise in raw materials prices; this had led to the recovery of substances from wast water, thus facilitating re-use and recirculation.

Figure 3.3.2. shows the trend of specific consumption by the whole of industry. Owing to the need to summarise production and water consumption of different industries in order to provide a picture relating to the entire industry, the volume of production is expressed in gross added value (against factor costs, in 1970 prices). In figure 3.3.3. the results of the survey are given in greater detail and related to physical production by industry.

3.4. Commercial, public, recreational and agricultural water demand (A3 + B3).

This group of water consumers includes the following sectors:
- agriculture and fisheries;
- building trade and electrical and sanitary engineering;
- commerce, hotel and catering trade, repair workshops;
- transport, storage and communication firms;
- banking and insurance, service industry (commercial);
- service industry (non-commercial).

These sectors consume mainly drinking water and fresh ground water. There is also some use of surface water for spraying and irrigation installations in the agrarian sector; however, such consumption falls outside the scope of the masterplan.

Water consumption by these sectors can be classified according to use as water for the following processes:
- hygiene;
- production and/or processing;
- food preparation;
- air conditioning;
- spraying and irrigation, and
- other purposes, such as cleaning and fire extinguishing.

For hygienic purposes and for the preparation of food drinking water is generally used. In the recreational sector and, in emergencies, in medical and similar institutions ground water won privately is also used for these purposes. For the other water-consuming activities both ground and drinking water are used, with a tendency to switch from drinking to ground water as more water is consumed; this is particularly true of airconditioning and spraying and irrigating activities.

As with industrial water consumption, there seem to be good grounds for assuming that water consumption is determined by the level of production in the different sectors. Yet, it is clear from figure 3.4.1. that in the past not only production but other factors too, must have played a part. However, research into factors that influence water consumption in these sectors has not yet reached the stage where the relevant factors can be clearly indicated. Notably the heterogenity of these sectors and the large number of institutions hamper progress of the investigation.

In principle it may be said that as more people are employed in a particular sector or make use of the facilities offered, water consumption for hygienic purposes and for the preparation of food in the sector will increase, and will decrease accordingly in the domestic and industrial sector, so that total water consumption remains the same. This shift may account for some of the rise in water consumption over the past decade, for the services sector, the commercial sector and the government departments have shown an appreciable increase in production and corresponding employment. In addition, water consumption has been influenced by the over-all improvement in the environment of the work place, which in large offices, educational establishments and suchlike included the installation of airconditioning plants. Here it should be noted that airconditioning plants of recent design no longer use water, which means that water consumed for this purpose is of diminishing importance.

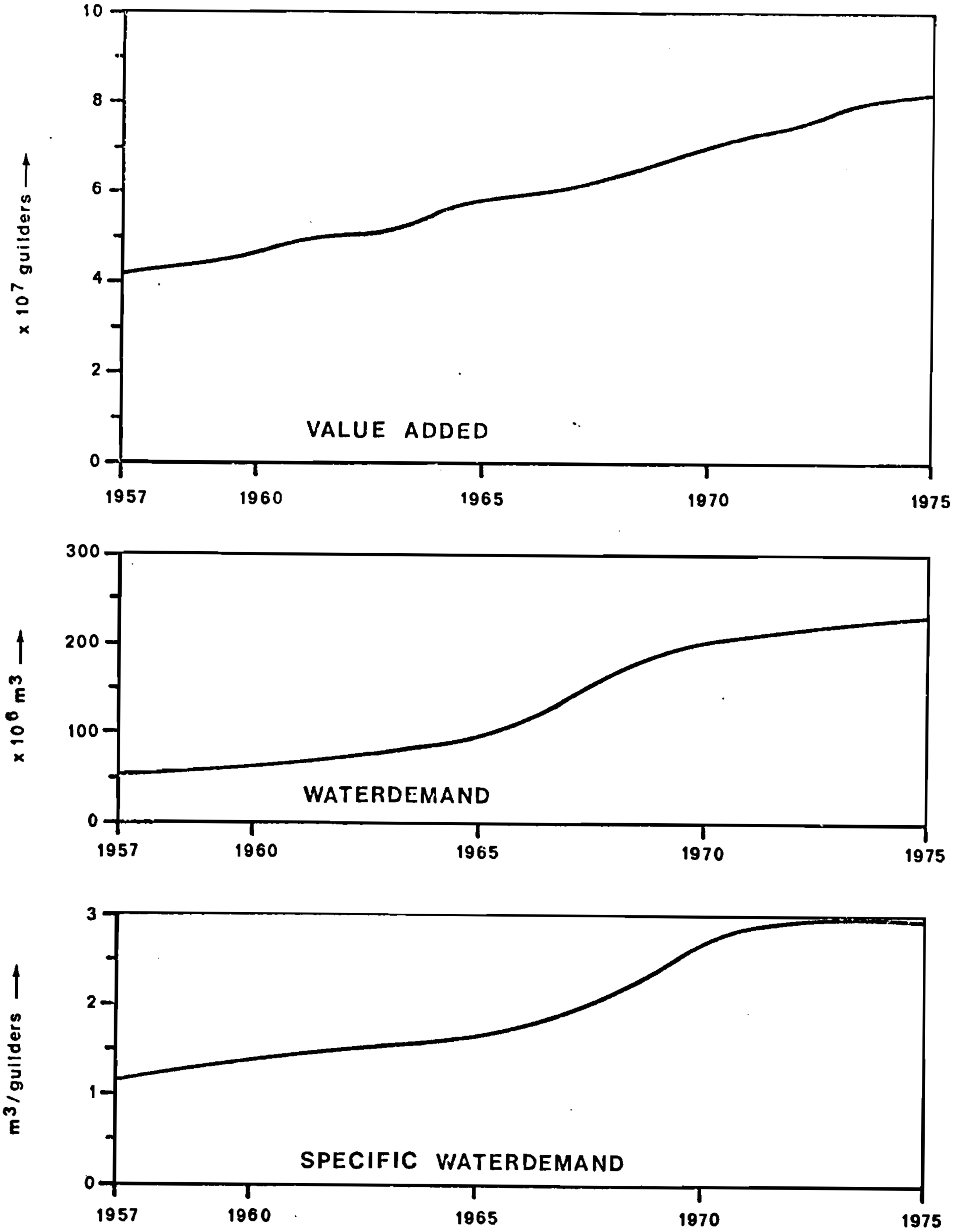

10
8
6
4
2
0
x 10^7 guilders →
VALUE ADDED
1957
1960
1965
1970
1975
300
200
100
0
x 10^6 m3 →
WATERDEMAND
1957
1960
1965
1970
1975
3
2
1
0
m3/guilders →
SPECIFIC WATERDEMAND
1957
1960
1965
1970
1975

FIGURE 3.4.1.

The considerable attention paid to man's wellbeing is also reflected by the increasing number of beds in the health service. In the period from 1965 to 1975 the increase in the population was 11.5 per cent, while the number of beds in the health services per head of the population increased by more than 50 per cent, which undoubtedly affected water consumption in this sector; notably consumption for food preparation and for hygienic and other purposes. Modernisation of hospitals further accentuated this effect on account of airconditioning plants.

More leisure has led to increased participation in active sports. Meeting the growing demand for suitable facilities meant a 90 per cent increase in the number of sports facilities between 1965 and 1976. Water consumption in this sector is determined mainly by the number of people using the facilities and - in the case of swimming baths and playing fields - climatic conditions.

Whereas climatic conditions are of minor importance in the services sector as a whole, in the agrarian sector they are of eminent importance. The use of advanced production techniques seeks to decrease dependence on the climate, so as to achieve a higher and more constant level of production. In recent years spraying and irrigation installations have been employed on an increasingly large scale, and have occasioned a sharp rise in water consumption, notably in the dry summer of 1976.

From all this it may be concluded that in the period under review water consumption per unit of added value has increased, but that the extent to which the various factors are responsible is not yet clear. With a view to gaining more insight into this question studies are being conducted in the sectors consuming most water. From surveys already performed a number of specific consumption data can now be determined. These are shown in tables 3.4.2. to 3.4.4.

Table 3.4.2.: Schools

Type of education	Average water demand (in m^3) per pupil year				
	1971	1972	1973	1974	1975
Nursery school	2.98	2.90	3.06	3.01	3.09
Primary school	1.71	1.77	1.73	1.78	1.82
Secondary school	1.61	1.77	1.48	1.41	1.46
Secondary trade school	3.44	3.27	3.17	2.79	2.63
Slow-learner school	4.10	3.54	3.78	3.79	4.03
High trade school	2.31	2.13	2.17	2.10	2.12

Table 3.4.3.: Universities

University	Number of students	Average water demand (in m^3 per student per year) (period 1974/1975)	
		Public water supply	Including own groundwater supply
Tilburg	3.3	9	-
Amsterdam	27.6	35	-
Utrecht	17.6	40	43
Groningen	12.5	56	-
Rotterdam	7.2	57	-
Leiden	12.5	69	-
Nymegen	11.9	77	-
Delft	9.6	87	133
Eindhoven	4.2	143	945
Wageningen	3.7	146	240
Enschede	2.1	157	-

Table 3.4.4.: Public Health Service

University hospitals	2.17 m^3 per patient-day
Other hospitals	0.63 m^3 per patient-day
Psychiatric hospitals	0.32 m^3 per patient-day
Hospitals for permanently retarded	0.33 m^3 per patient-day
Nursing homes	0.3 m^3 per patient-day

3.5. Other water demand (A4).

By other water demand is meant the difference between the volume of drinking water which is delivered to the supply area and that which is bought by the consumers. This consumption comprises loss in transmission arising from leakages in transmission, main and service pipelines, and water used for flushing the network. In so far as it is non-metered, this also includes water used for fire extinguishing, spraying public parks and gardens, etc. Loss from leakages occurring in internal piping is included in the water consumption of the category in question.

Other water demand has undergone a less sharp rise than the other categories. Calculated as a percentage of domestic, industrial and commercial, public, recreational and agricultural water demand, it shows a relative decline from 10.9 per cent in 1969 to 8.5 per cent in 1975.

The reasons why this consumption has lagged behind that of the other categories are the decrease in loss from leakage and the reduced frequency with which the network is flushed. The relative decline in leakage loss is explained by the improved pipeline material (other consumption dropped from 1062 m^3/km pipeline in 1965 to 1046 m^3/km pipeline in 1975) and the fact that the increase in water consumption was not attended by a corresponding increase in the length of the supply network 51 and 32 per cent respectively between 1965 and 1975). The reduced frequency of flushing is due to the more intensive utilisation of the network and improved purification technology.

In 1969 other water demand was 70.7 million m^3 compared with 79.2 million m^3 in 1975.

4. Forecasting drinking and industrial water demand.

4.1. Forecasting in practice.

Till recent years in the Netherlands various types of trend extrapolation generally were used for all prognosis of the future water demand. A short discription is given.

Time series extrapolation consists of obtaining data for past years, observing their trend and extrapolating it for future years. Linear extrapolation is most frequently used, but various non-linear functions may be appropriate for cases of rapidly increasing (or decreasing) use. This method can be expected to give quite accurate results if forecasting is for a relatively short period into the future and the time series trend is quite regular. Although all these forecasting methods are based on the assumption that relevant conditions do not change, or change in a known or predictable manner, time series extrapolation is perhaps more vulnerable with respect to this assumption than other forecasting methods. In pure time series extrapolation, no account is taken of anything except the trend of past observations. In some applications greater weight is placed on more recent observations than on earlier observations. For this purpose, exponential smoothing, moving averages, or similar techniques may be used, but these approaches are difficult to justify unless some rationalization can be given for the weighting used. Such a rationalization must usually depend on knowledge concerning related variables or changing social-economic conditions.

In order to overcome, at least partially, some of the inadequacies of time series extrapolation, forecasting of water requirements is frequently based on changes in the values of other variables over time. For example, population, income, industrial growth, cost (including costs of pollution control), are frequently used as explanatory variables in a multiple regression equation to predict water use. In some cases, multiple regression is used to predict use by sectors, for example household and industrial, and total water use is obtained as the sum of these sector uses.

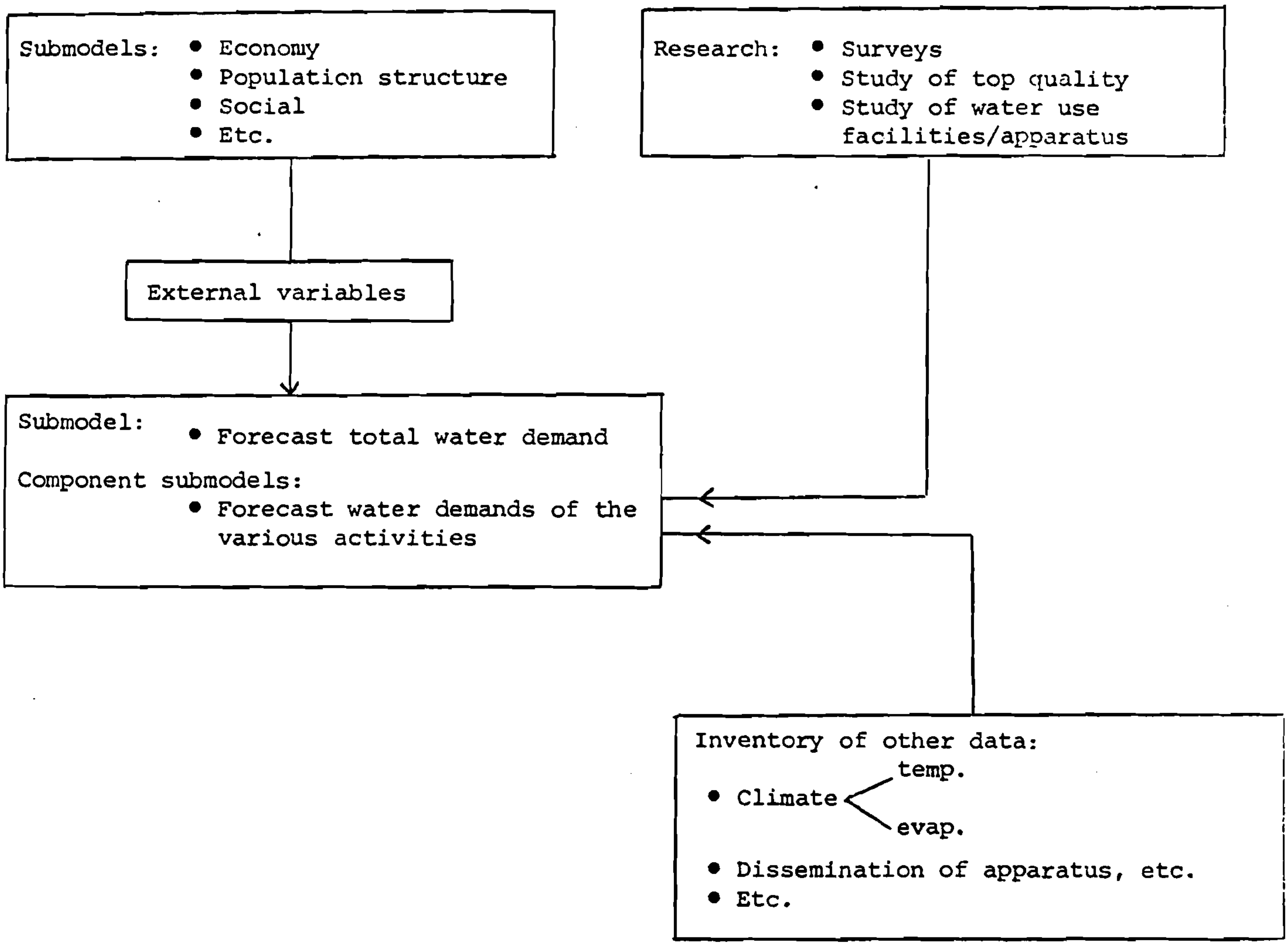
In the Netherlands the Rijksinstituut voor Drinkwatervoorziening (National Institute for Water Supply) practices the Component Method of Forecasting at this moment. This method involves four steps:

a. identifying the volumes of water used for different purposes;
b. forecasting the development of variables which affect water demands;
c. forecasting the amount needed for each individual purpose in the future;
d. adding these separate volumes to obtain a forecast of total demand.

4.1.1. Forecasting water demand of households.

Figure 4.1.1.1. shows the framework for forecasting water demand of households.

Figure 4.1.1.1.



The household water demand forecast submodel is composed of component submodels:

- Toilet flushing : $WT_i = B_i \cdot ST_i \cdot VT_i$

where WT_i = total water demand in year i for toilet flushing;
B_i = number of population in year i;
ST_i = average weighted frequency of toilet flushing per person in year i;
VT_i = average use per flushing in year i.

- Personal washing : $WL_i = B_i \cdot \sum_{n=1}^{3} (SL_{i,n} \cdot VL_{i,n})$

where WL_i = total water demand in year i for upkeep;
B_i = number of population in year i;
$SL_{i,1}$ = average weighted number use of wash basins per person in year i;
$SL_{i,2}$ = average weighted number use of shower per person in year i;
$SL_{i,3}$ = average weighted number use of baths per person in year i;
$VL_{i,1}$ = average demand per personal wash in year i by use of wash basin;
$VL_{i,2}$ = average demand per personal shower in year i by use of shower;
$VL_{i,3}$ = average demand per personal bath in year i by use of bath.

- Washing : $WW_i = B_i \cdot \sum_{n=1}^{2} (SW_{i,n} \cdot VW_{i.n})$

WW_i = total water demand in year i for washing;
B_i = number of population in year i;
$SW_{i,1}$ = average weighted number of hand washing person in year i;
$SW_{i,2}$ = average weighted number of machine washing per person in year i;
$VW_{i,1}$ = average weighted demand per hand washing in year i;
VW_i = average weighted demand per machine washing in year i.

- Dishwashing: $WA_i = B_i \cdot \sum_{n=1}^{2} (SA_{i,n} \cdot VA_{i,n})$

WA_i = total water demand in year i for dishwashing;
B_i = number of population in year i;
$SA_{i,1}$ = average weighted number of hand washing per person in year i;
$SA_{i,2}$ = average weighted number of machine washing per person in year i;
$VA_{i,1}$ = average demand per hand washing in year i;
$VA_{i,2}$ = average demand per machine washing in year i.

- Car washing : $WB_i = B_i \cdot SB_i \cdot VB_i$

WB_i = total water demand in year i for car washing;
B_i = number of population in year i;
SB_i = average weighted number of car washing per person in year i;
VB_i = average demand per car washing in year i;

- Sprinkling : $WE_i = B_i \cdot SE_i \cdot VE_i$

WE_i = total water demand in year i for sprinkling;
B_i = number of population in year i;
SE_i = average weighted number of sprinkling per person in year i;
VI_i = average weighted demand per sprinkling period in year i.

The addition of these component water demands gives the total water demand of households in every area which are considered:

$$W_i = B_i \cdot (WT_i + WL_i + WW_i + WA_i + WB_i + WE_i)$$

4.1.2. <u>Forecasting, industrial, commercial, recreational and public water demand.</u>

The forecasting of this demand includes the product of the specific demand of the several branches or groups and the production or activity level. Future production level of existing factories is taken from an economic model of the Centraal Planbureau (Bureau for Central Planning). This model includes the variables of import, export, capital investment, household expenditure, etc. This forecasting of industrial activities gives production level for each branch, group or subgroup of the industry.

For example the unit values of water demand were expressed in m^3/ton and the total water demand of the industry branch may be calculated based on production volume in tons.
At this moment unit values are also tried to be converted in m^3/ guilder, and the total water demand of the branches and groups may be calculated based on production value in guilders.

The equation for calculating the industrial water demand in the year i is given below:

$$W(I)_i = \sum_{j=1}^{n} P_{i,j} \cdot (WP_{i,j} + WK_{i,j});$$

$W(I)_i$ = water demand in year i;
$P_{i,j}$ = production in physical unit in year i and branch j;
$WP_{i,j}$ = specific water demand in process in year i and branch j;
$WK_{i,j}$ = specific water demand for cooling in year i and branch j;
n = number of branches.

When production cannot be given in physical unit $P_{i,j}$ may be evaluated with value added from the equation:

$P_{i,j} = r_{i,j} \cdot TW_{i,j};$
$r_{i,j}$ = factor
$TW_{i,j}$ = (gross) value added in year i on branch j;
$P_{i,j}$ = industrial production in year i on branch j.

To give a more detailed description of the relations between industrial water use and the factors which influence it, at this moment we draft more detailed equations which are not yet practiced:

$$V(I)_i = \sum_{j=1}^{n} V(I)_{i,j};$$
$$V(I)_{i,j} = W(I)_{i,j} + H(I)_{i,j}$$
and $$W(I)_{i,j} = L(I)_{i,j} + EW(I)_{i,j}$$

in which:

$V(I)_{i,j}$ = water use in year i on branch j;
$W(I)_{i,j}$ = water demand in year i on branch j;
$L(I)_{i,j}$ = public water supply in year i on branch j;
$EW(I)_{i,j}$ = own water supply in year i on branch j;
$H(I)_{i,j}$ = reuse of water in year i on branch j.

In the following functions a "+" before a factor indicates that increasing this factor increases the level of the commodity on the left-hand side of the equation (e.g. an increase in Kn EW causes $H(I)_{i,j}$ to increase). In a similar way a - before a factor indicates that increasing this factor decreases the commodity on the left-hand side.

$H(I)_{i,j}$ = function [-Kn H, + Kn EW, + t, + $V(I)_{i,j}$, + Kn waste]
$EW(I)_{i,j}$ = function [-Kn EW, + Kn H, + t, + $V(I)_{i,j}$]

Kn H = costs of reuse;
Kn EW = costs of own supply;
t = water supply charges;
Kn waste = cost of discharge waste water.

= $V(I)_{i,j}$ = function [+$P_{i,j}$, + C, - KnW, + om2, + substit, - T2]

C = constant demand;
KnW = weighted costs of water;
on2 = laws specifying acceptable water quality in food processing;
substit = costs of substitute articles;
T2 = water saving technology;

KnW = function [+ t, + $L(I)_{i,j}$, + KnEW, + $EW(I)_{i,j}$, + Kn H, + $H(I)_{i,j}$, + Kn waste, - Kn oprofac]

Kn oprofac = production costs (excluded water) inside the factory.

KnEW = function [+ input kn EW, + om4, - T_1, - gun 1]

input kn EW = fixed and variable costs of own supply;
om4 = extra costs of rules of groundwater management;
T_1 = technology of water pumping and treatment process;
gun 1 = quality of raw water.

KnH = function [+ input Kn H, - T_1]

input Kn H, fixed and variable costs of reuse.

t = function [+ input Kn L, + pp]

input Kn L = fixed and variable costs of public supply;
pp = price policy.

C = function [+ cap, - KnW, + l, -m]

cap = production capacity of the industry;
l = number of labours;
m = mentality.

gun 1= function [+ oml, + gun2]

oml = laws which regulate water pollution;
gun2 = quality of ian waste which comes over the frontier.

T2 = function [+ $P_{i,j}$, KnW, + T_3]

T_3 = water decrease by changes (e.g. technology).

In principal we could use this submodels for the different size of areas (total country, region, province, city area). In practice the model cannot be used on an area smaller than a region of the country because of the aggregated nature of the data in the economic model.

4.1.3. Other water demand.

Agriculture water demand.

Agriculture water use has been analyzed very thoroughly in recent years, especially by institutes which are specialized in agriculture studies.

Only a **relative** small part of the demand of this type of water use is included in the master plan, especially the public water supply.

4.2. Future domestic water demand (A1*)

In view of what has been stated in paragraph 4.1., we shall indicate by reference to a number of developments in what manner and to what extent the factors mentioned in paragraph 3.2. are capable of changing. Subjects to be discussed in this context are:
urbanisation, types of dwellings, water-consuming appliances, outlook and size of households.

a. Urbanisation
The policy of the Netherlands' government will only become apparent after some time. In the western part of the country, in particular, further development of urbanised rural municipalities and dormitory towns will continue for the present.
This means a relatively larger proportion of new dwellings in these areas.
In the longer term, with a decline in growth rate of the population, there may be a further development of residential areas in existing concentrations.

b. Types of dwellings
After the Second World War, housing policy was more concerned with quantity than with quality. The building of relatively inexpensive dwelling units did, however, mean limited differentiation, which also applied to kitchen equipment and sanitary facilities.
The average quality of these facilities also affects houses now being built. However, since new property represents only a fairly small proportion of the total supply of dwellings, this influence will be slight for the present. In the longer term building work will concentrate on bringing the quality of existing dwellings into line with the new living pattern and housing standards.

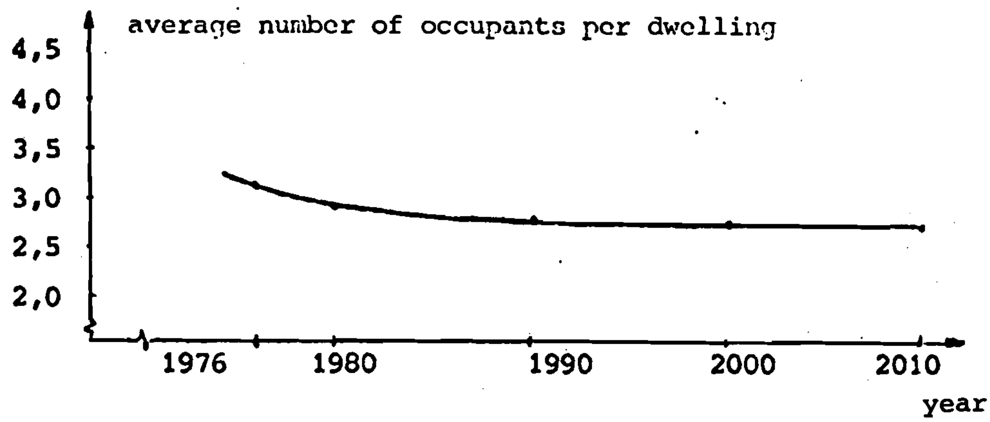
c. The increased prosperity of the last years is reflected in the virtual doubling of private consumption per head of the population. One of the consequences of this is that a larger group of households can afford to purchase domestic appliances, including those that consume water. This shows that the needs of the consumer rapidly adapt to what comes within his reach. This generally results in the presence in a household of a kind of standard package of facilities and appliances. As real private consumption is expected to stabilise or increase only slightly, this trend will be retarded in the future.

d. The growth in various fields witnessed in the last decade or two has gradually led to a fuller realisation of its limits, notably on account of environmental effects and exhaustion of raw materials. Water consuming operations also have a direct or an indirect influence on this. Whether this awareness will result in developments restricting the use of water will depend on the willingness of the consumer to attune his optional behaviour to this awareness. A potentially important factor in all this is the "dispensability" of a particular appliance. A washing machine, for example, generally merits the rating "(absolutely) indispensable", whereas this is far less true of a dishwasher. This aspect is bound to affect the degree of penetration of domestic appliances.

Already noticeable among the developments in regard to living as a family is that a growing category of people find it impossible to develop adequately in such a set up. In consequence, more extremely small households are likely to be found. Moreover, more women are expected to take on jobs, and this may increase the need for more efficient and/or automated domestic chores and the purchase of (water-consuming) appliances.

e. One datum that has to be taken into account in determining future domestic water consumption is the average number of occupants per dwelling. As is evident from figure 4.2.1., the downward trend of the next two or three decades is expected to stabilise in the future at around 2.7 occupants per dwelling.

Figure 4.2.1.: Future average number of occupants per dwelling.



The effect of the trends we have outlined on the different elements of domestic water consumption may now be translated into a quantification of the respective specific consumption data. As in paragraph 3.2., consumption has been divided into five categories.

A - Personal hygiene

. The tendency to install cisterns with a slightly reduced water consumption will persist, though on a smaller scale. Especially where the old, usually large, cisterns are replaced by new ones, average consumption and, in particular, the spread in consumption will become less. This should result in average water consumption for each toilet flushing dropping to 7 litres.
In the period covered by the plan the working population, as a percentage of the total, is expected to remain the same or to decrease.
As a result, use of the toilet at home may increase slightly. It has been assumed that this effect will be more or less neutralised by the tendency for more prolonged education and training, causing the persons concerned to be away from home more often and for longer periods.

Partly owing to increasing consumption the average frequency of toilet flushing is expected to increase to 4.5 times per person per day. Specific water consumption for toilet flushing in the home will then be 32.5 l/hxd.

- Water consumption per ablution at the wash-basin is not likely to change in the future. Frequency, on the other hand, will probably decrease to 8 times a week, owing to increased availability and more frequent use of bath and shower. This will result in a specific consumption of 4 l/hxd.

By the year 2010 the availability of shower and bath is expected to reach 62 and 38 per cent respectively. Because of changes in attitude and different utilisation of time, the frequency of use will increase somewhat to 4.5 and 3.5 times per person per week respectively, whilst as regards consumption per ablution only baths are expected to show an increase, viz. to 150 litres a time. This will result in a specific consumption of 52 l/hxd. Total specific water consumption for personal hygiene will thus amount to 56 l/hxd.

B - Laundering

As stated earlier on, the penetration degree of washing machines, around 85 per cent, has virtually reached saturation level. With the decrease in the size of housholds the number of households will increase. This means that the penetration degree is likely to decrease rather than increase, but the actual number of machines will problably increase.

In the medium-long term water consumption per washing programme is expected to decrease as a result of the larger proportion of machines with reduced water consumption. Although there will also be a shift as regards the type of article washed, it has been assumed that this will not affect water consumption and that there will be no need to change the frequency of manual washing.

In consequence of the developments outlined here, average water consumption per washing will decrease to 115 litres. With an average occupation of 2.7 persons per dwelling unit, the frequency is 4 washings a week. From this follows a water consumption of 25 l/hxd. Together with a consumption of 2 l/hxd for manual washing, this gives a specific water consumption for laundry purposes of 27 l/hxd.

C - Food preparation, dishwashing, etc.

Neither in regard to the direct and indirect consumption of water, nor consumption for the preparation of food are such developments expected that the relatively small consumption figures of 1 and 3 l/hxd will undergo significant changes. As there is as yet no evidence of any development which will reduce the water consumption of washing machines, the previous figure of 40 litres per washing has been retained. With the decrease in the size of households there will be relatively more washing machines in the future. By the year 2010 the penetration level is expected to reach about 25 per cent. Some change in the frequency of manual dishwashing to twice may be expected. Consumption will increase to 18 litres a time. The frequency of use of the dishwasher is maintained at five times a week. In households with a dishwasher, manual dishwashing will continue to average once a day with a water consumption of 10 litres.

Future average per capita water consumption in households with and without a dishwasher will accordingly amount to 19 and 13.5 l/hxd. Specific water consumption then works out at 15 l/hxd.

D - The relatively small consumption of water for cleaning the house remains the same at 1 l/hxd, since no major changes are expected in these operations.

E - In the next few years the proportion of new high-rise dwellings will be smaller than at present. This means a growing number of homes with gardens. Moreover, there is a trend towards both larger gardens and increased use of automatic sprays. Both involve higher water consumption. As a consequence, average consumption for watering the garden will rise to around 2.5 l/hxd.

According to present information the number of private cars will reach saturation point in the '80s. As the motorcar will increasingly become a utensil, the frequency of washing will probably become less. On the other hand, water consumption per wash will increase, as more use is made of the hose. Lastly, there are indications of more frequent use of car-wash stations.

Also worth mentioning is water consumed in tending potted plants. The quantity involved has risen relatively sharply with the more widespread practice of heating several rooms in the house, notably with the installation of central heating, and the presence of more and larger plants.

In table 4.2.2. anticipated specific uses in successive years are tabulated.

Table 4.2.2.: Specific water consumption.

category \ year	today	1980	1990	2000	2010
A - . using the lavatory	32	32	33	33	33
. personal hygiene	34	35	44	48	56
B - doing the laundry					
. hand	2	3	2	2	2
. machine	21	22	23	24	25
C - . preparation of meals etc.	3	3	3	3	3
. dishwashing	11	12	13	14	14
. consumption	1	1	1	1	1
D - cleaning the home	1	1	1	1	1
E - other activities	1	1	2	3	4
Total (l/hxd)	106	110	122	129	139

4.3. Future industrial water demand (A2* + B2*)

Of the various methods for determining future water consumption described in paragraph 4.1. the trend method was chosen for this report. It presupposes insight into the production prognosis as well as the trend of specific consumption by industry.

For the production prognosis use is made of the results of calculations with economic model of the Central Planning Office.

In consultation with industrial enterprises and industrial associations involved in the afore mentioned survey prognoses of specific consumption figures were drawn up. In order to enable the forecast for industry as a whole to be compiled from the individual prognoses of the different industries, the common denominator "added value" was adopted for production. In drawing up the prognoses of specific water consumption a number of assumptions were made regarding the trends of the factors mentioned in paragraph 3.3.

- The effects of production volume, production capacity and number of employees have in part been incorporated in the production of Dutch industry. In addition, the production volume/production capacity ratio affects the specific water consumption of a number of industry groups. Besides a consumption proportional to production, there is the matter of constant consumption. Plant has to be cooled or heated, even if less or nothing is produced. This takes cooling water or steam as constant consumption. For the industries in question normal degrees of utilisation have been assumed. These are often round about 85 per cent of maximum production capacity.
  Water consumption for sanitary purposes is largely determined by the number of employees. For all industry the quantity is small. Relatively large fluctuations are of minor importance in determining total industrial consumption. It has been assumed that this effect will remain at the 1976 level, with possibly a very slight increase owing to improved sanitary provisions in factories.

- Much importance is attached to the price of water, at least where the total costs of water management in industrial establishments is considered. These costs can be broken down into the cost of producing or buying water, the cost of treatment before or after use, and the cost of discharge.
  - Producing and buying water.
    Up till now there has been no charge for recovering ground water. In connnection with expected new legislation, allowance has been made where possible in drawing up the prognoses for a small levy. Besides a levy on the recovery of ground water, the cost of energy is important, for indirectly energy costs are of considerable influence. Cooling by any means other than ground water, usually consumes more energy. A sharp rise in energy costs will, therefore, have the effect of increasing the cost of recovering ground water for cooling prices.
    In the survey among factories it was found that allowance is made for this sharp rise in costs. For many industrial establishments this has proved a deterrent to switching over to alternative methods of cooling.
    Investment costs are a factor when expansion or replacement of ground water recovery is contemplated. Where financial resources are limited a slight shift from private recovery of ground water to delivery by the public water supply (tap-water) could be decided on, in which case there would be no need for investment, but - instead - annual costs would increase. However, the effect on

private recovery is thought to be slight.
Levies play no part in the use of surface water for processing purposes. Neither are energy and investment costs of much importance. However, for other reasons surface water is seldom an alternative to ground or tap-water. Compared with ground water, tap-water is relatively expensive to buy. In drawing up prognoses for firms that use tap-water - often because they have no choice - we have made allowance for an increase in tap-water rates, which is in excess of the rise in the average price level. The reason for this is that more than 60 per cent of industrial consumption of tap-water is in areas where the water supply companies now use surface water, or will be doing so in the near future. A sharper rise in the rates is expected because there are some misgivings as regards the quality of the surface water.

. Water purification by industry.
When ground water is used, purification generally consists of no more than demineralisation. Only for special processing purposes and for use as boiler feed water is any further treatment necessary. The costs of this are compounded of investment costs, energy costs, labour costs and the cost of chemicals. As far as the two former items are concerned, the same **applies** as mentioned under recovery. In the case of the two latter items extra cost increases have not been taken into account.
Industrial establishments now using and purifying surface water are large establishments situated in places where good ground water is not available in sufficient quantities. A possible alternative for such establishments would be to use a large volume of mains water which is expensive, locally. Any increase in the cost of purification will not, therefore, bring about changes in the source of the water supply. Since surface water purification is often complicated and expensive, satisfactory industrial water management will generally be in existence, so that the expected increase in the cost items for purification are likely to have very little influence on consumption. Purification of tap-water is customary only for special processing purposes and for boiler feed.

. Costs of discharge and purification after use.
These costs cannot be considered separately. An industrial establishment will invariable ascertain what is economically more advantageous: captive purification or paying discharge costs. In the period from 1970 to 1976 discharge costs increased with such rapidity that more firms adopted internal measures to limit pollution both quantitatively and qualitatively. Captive purification did admittedly incur additional costs, but in many cases this worked out considerably cheaper than paying the levy. Often, an additional advantage was that water of reasonable quality became available, which was suitable for re-use. For the future, up to about 1985, a continued sharp rise in the levy on discharge has been reckoned with.

- Quality of the available water.
The division of total consumption into ground, surface and tap-water depends up to a point on the quality of these sources. Relative to the present situation the quality of ground water is not expected to change much, at least not to the extent that its use by industry will either decrease or increase. Firms using surface water do expect some

worsening. The consumption of surface water for boiler feed water will increase somewhat owing to larger purification and discharge losses, but not to the extent that this needs to be taken into account. With continued worsening of surface water there is a considerable likelihood that firms now using surface water for purposes other than cooling will increasingly switch to tap-water. In the event of certain surface waters showing improvement, it is conceivable that some firms will change to surface water instead of the tap-water they are using now. These possibilities have to be taken into account in assessing the share of water to be supplied by the water supply companies in total consumption. However, they are not expected to have any significant effect on total consumption.

- Technology.
  Following new legislation on waste water discharge and recovery of ground water, industry has been paying considerable attention to industrial water management in the last 6 to 7 years. As a result, substantial economies have been effected. In many industries specific water consumption has fallen sharply, often by more than half, in some cases to around 10 per cent of the volume used in the 1950 - 1960 period. In some industries, however, consumption has almost dropped to the level where any further saving is possible only at a high cost. In the food and allied industry a lower limit is set in some cases by regulations concerning hygiene.
  In most industries some further decline in consumption is expected, but not on the scale of 1970 - 1976.
  In some industry groups (including textiles and plastics) changing process technologies using more water for humidification of the air, etc., are expected to lead to higher specific consumption. Further investigation will in due course provide more information about this.

- Mentality.
  Besides the effect produced by closer attention to the cost and technology of industrial water management, consultation with industry during the preparation of the legislation mentioned in the preceding paragraph also had its effect on the mentality. That alone has brought about the expected reduction in water consumption. Wasteful consumption such as that caused by taps left running unnecessarily, etc., has been stopped by such simple remedies as the use of self-closing taps, spraying jets, etc. Generally, the obvious measures have already been taken. Continued discussion of the need for efficient use of water will be necessary to keep attention focused on this subject. In some instances it has been found that initially disciplined use of water reverts to a certain carelessness in use.

- Government measures.
  Apart from measures that affect cost, such as levies, etc., the Government can also impose restrictions on the recovery of ground and surface water. It should be remembered that this will not always result in decreased consumption. In many cases it will cause a shift towards tap-water, provided production is tied to a particular location. In other cases the company is likely to seek expansion of production elsewhere, possibly outside the Netherlands. We may

assume that, in either case, this will have the effect of increasing the costs. In certain cases, however, the company will be able to introduce an alternative process, one which requires less water, if any. A case in point is plant cooled with ground water. For new plants techniques are available which, depending on temperature level and the necessary temperature differential, scarcely increase costs. Obviously, the conversion of existing plant is more costly.
In the prognosis of specific water consumption we have allowed for a further decrease in fresh ground water consumption for cooling purposes only. For the present, this decrease has been estimated conservatively. A further survey now being conducted in collaboration with industry and the provinces should indicate what degree of limitation is possible in this direction.

Summarising, it may be said that a further reduction of specific water consumption is feasible and likely in many industry groups. As some of the potential for reduction is already being utilised or will be in the near future, the rate of decrease is expected to diminish.
In figure 4.3.1. production, specific consumption and water consumption by industry as a whole is plotted against time. For a number of sub-industries figures 4.3.2. to 4.3.6. forecast specific consumption.

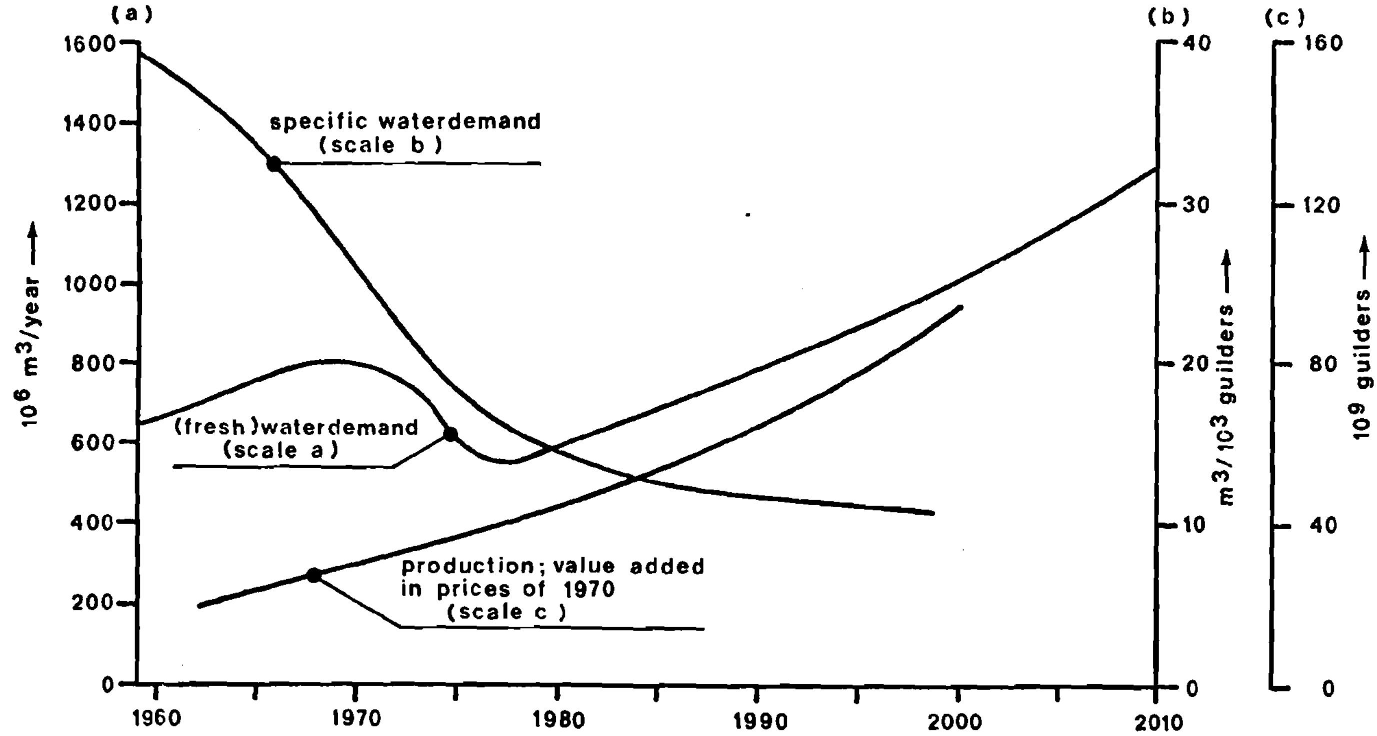


FIGURE 4.3.1.

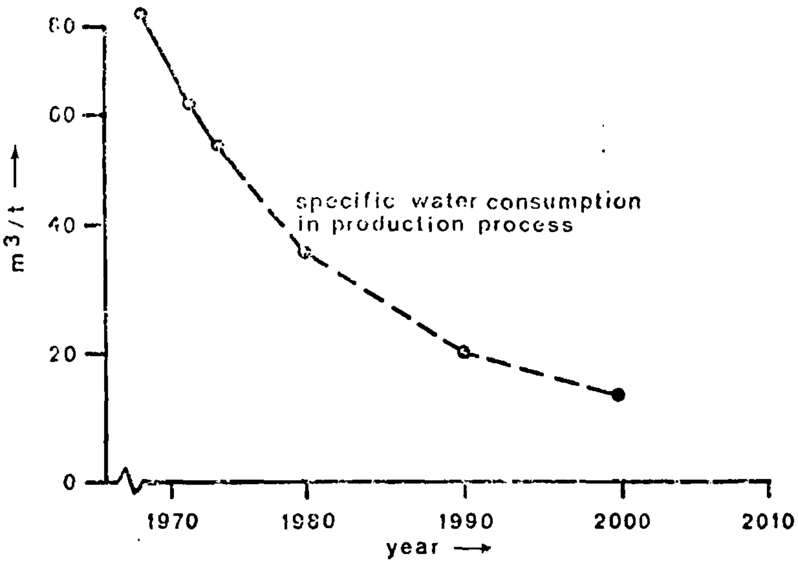


FIGURE 4.3.2.
SPECIFIC WATER CONSUMPTION IN THE PAPER INDUSTRY

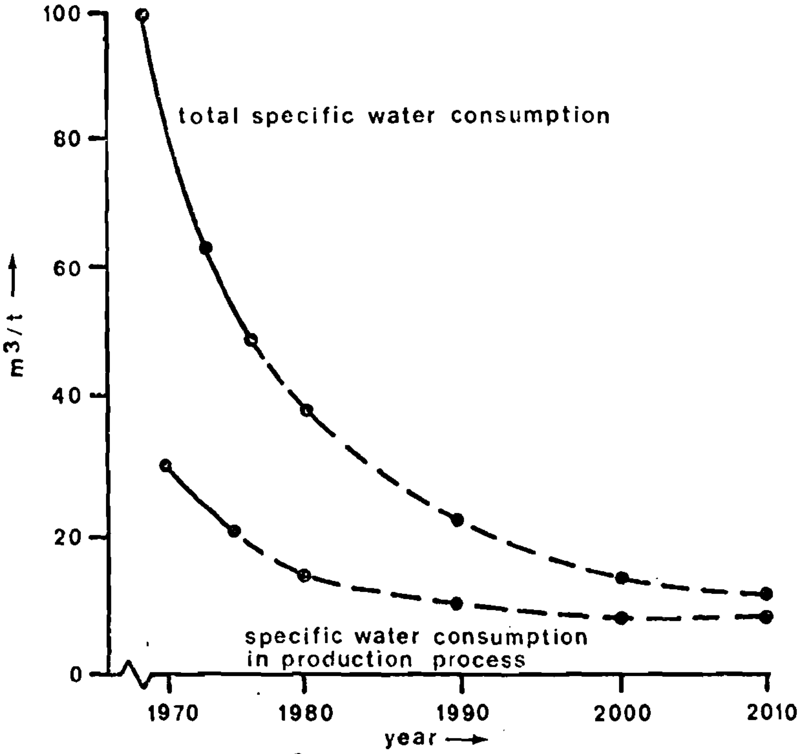


FIGURE 4.3.3.
SPECIFIC WATER CONSUMPTION IN THE POULTRY INDUSTRY

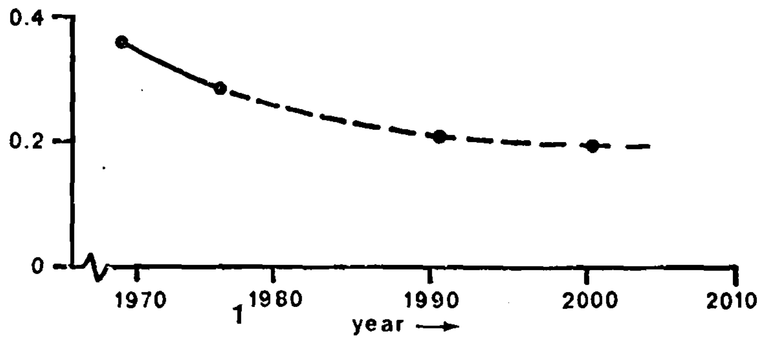


FIGURE 4.3.4
SPECIFIC WATER CONSUMPTION IN OIL REFINERIES

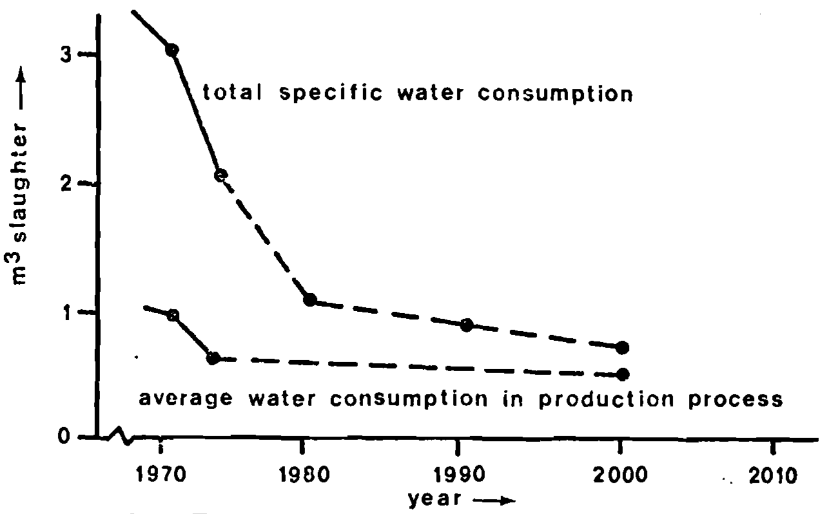


FIGURE 4.3.5.
SPECIFIC WATER CONSUMPTION IN SLAUGHTERHOUSES

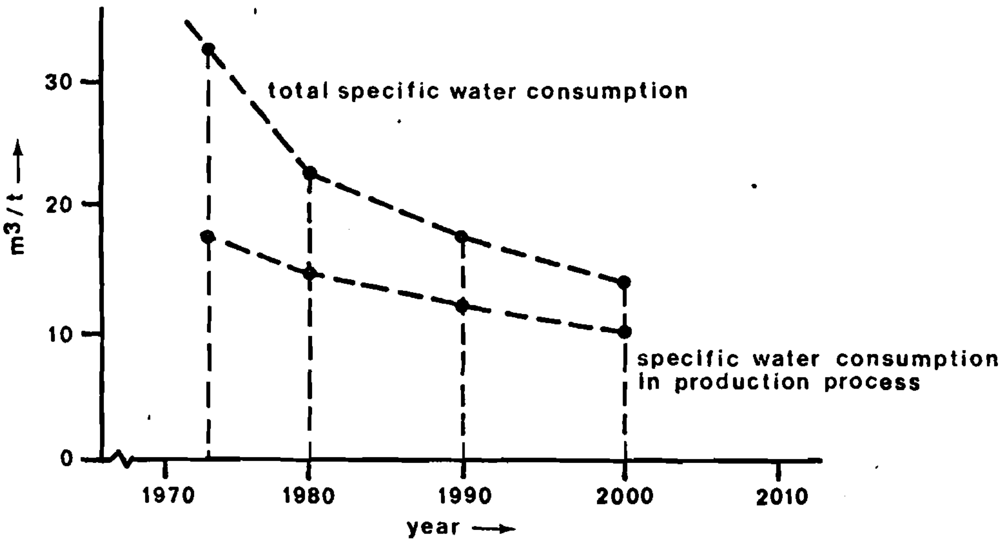


FIGURE 4.3.6.
SPECIFIC WATER CONSUMPTION IN MEAT PROCESSING INDUSTRY

4.4. Future commercial, public, recreational and agricultural water demand ($A3^{x} + B3^{x}$)

In describing the trend of water consumption by these sectors in paragraph 3.4. it was found that knowledge of those factors that are capable of influencing consumption is still limited. The prognosis will, therefore, be more in the nature of an indication.

Water consumption in these sectors is determined by the level of activity there. As an indicator of activity we chose the added value, and as a measure of water consumption the specific consumption; future water consumption is ultimately determined by the trend of both these indicators.

It is assumed that in the coming decades structural changes in tap-water consumption, reflected in specific consumption, will not occur on the same scale as in the past, but that specific consumption will continue to increase.

The growing attention paid to personal hygiene, with its anticipated effect on domestic water consumption, will also have an impact on consumption in the commercial, public, recreational and agricultural sectors, especially as a result of the provision of more extensive washing facilities for personnel in the service industry. In addition, allowance must be made for the use of new water-consuming production techniques in, for example, the health service, industrial cleaning services and in the agricultural sector. In view of the expected increase in leisure, more intensive use is likely to be made of existing facilities for sport and recreation, while new, possibly water-consuming facilities will probably be developed. Finally, the tendency for more extended education may increase specific consumption by educational establishments, in so far as this trend has not already been discounted in the production trend of this sector. All these factors combined suggest a **specific** consumption of tap-water of 3,75 m^3 per unit of added value in the year 2010.

For the purpose of determining future water consumption, the units of specific consumption and production have been combined. In table 4.4.1. the results in respect of tap-water consumption are set out. In addition, these sectors will recover some 50 million m^3 of ground water.

Table 4.4.1.

	1980	1990	2000	2010
specific consumption of tap-water ($m^3/10^3$ gld.)	3.1	3.3	3.5	3.6
gross added value (10^9 gld.)	99.7	140.9	180.7	
tap-water ($10^6 m^3$)	300	460	630	830

4.5. Future other water demand (A4*).

Other water demand will continue to be caused mainly by leakage losses in transmission, main and service pipelines and by flushing of the network. Considering the steadily improving quality of the pipeline material that will be increasingly used, and the improved methods for tracing and repairing leaks, leakage losses are unlikely to increase more rapidly than they have done in recent years. The need to flush the pipeline network is expected to arise with the same or reduced frequency, mainly as a result of increasingly intensive use of the system. By reason of the foregoing, a slight downward trend is expected.

For the year 2010 other use is estimated at 7.5 per cent of tap-water consumption by categories A1, B1 and C1, or about 130 million m^3.

5. Total future drinking and industrial water demand in the Netherlands.

Total fresh water consumption, excluding cooling water from surface water, and excluding private recovery in agriculture, but including priviate recovery of both ground and surface water by industry and by the sectors commercial, public, recreational and agricultural is shown in table 5.1.

Table 5.1.

territory	year				
	1976	1980	1990	2000	2010
demand (x $10^6 m^3$)	1474	1590	2008	2532	3091
size of population (x 10^6)	13.7	13.9	14.6	15.2	15.3