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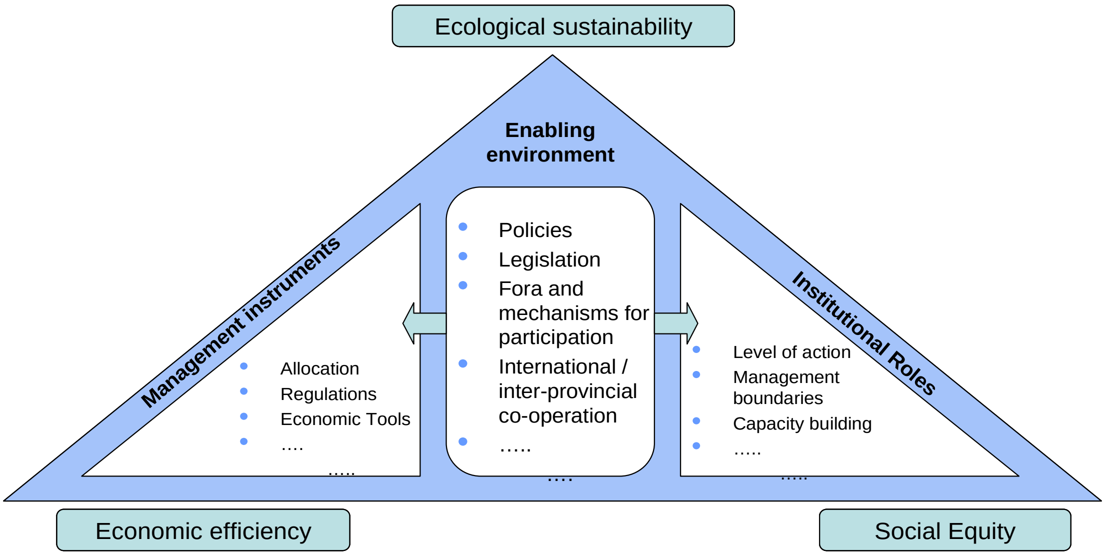
China – UK, WRDMAP Integrated Water Resources Management Document Series

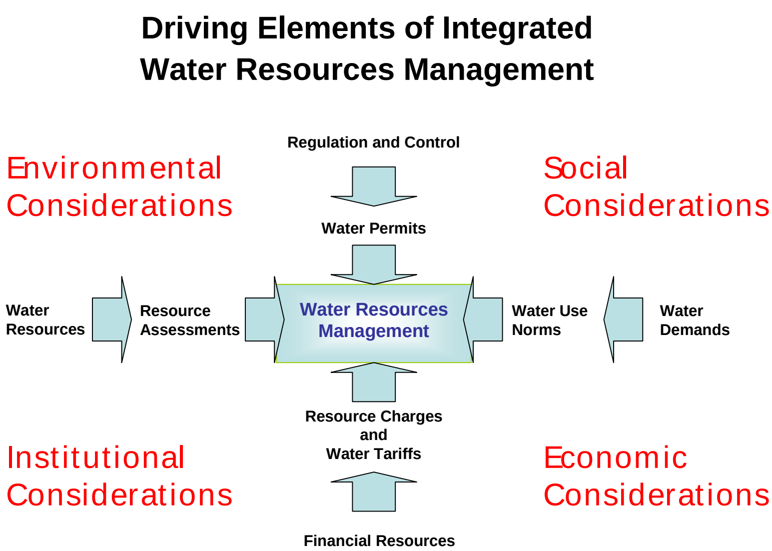
Advisory Note 1.8/1: Water Demand Forecasting

May 2010

Integrated Water Resources Management (IWRM)

(Basics after Global Water Partnership)





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Summary: This paper provides guidance for forecasting water demand for both urban and rural environments. It introduces the principles, procedures and precautions for the calculation of a water demand forecast.

The Paper includes domestic, industrial, and eco-environmental water demands. It introduces some preparatory activities that are required before a water demand forecast analysis, and it provides the steps of a demand forecast calculation according to a norms approach.

This Advisory Note comprises:

- Concepts, methods, principles
- Preparation of water demand forecast
- Socio-economic development indicators
- Socio-economic water demand forecast
- Eco-environmental water demand forecast
- Aggregation of water demands
- Requirements summary
- Rational analysis of forecast results

This document is one of a series covering topics on sustainable water resources planning, allocation and management. Details are given in the bibliography.

The Ministry of Water Resources have supported the Water Resources Demand Management Assistance Project (WRDMAP) to develop this series to support WRD/WAB at provincial, municipal and county levels in their efforts to achieve sustainable water use.

1 Introduction

The situation of scarcity of water resources is becoming increasing serious in the world today as well as in this country. Although people try their best efforts to improve water supply, it still cannot always meet the water needs of economic and social development let alone the environment. Serious water shortage has often become the impediment of regional economic development. The fierce competition among various economic and social activities for water can cause social contradictions and injustices and undermine the construction of harmonious society. The conflicts between economic water consumption and ecological water requirements can be serious. This often results in continuous environmental degradation or even causes the ecology system to collapse. Such situations, or potential situations, are becoming too numerous to mention.

The increasing imbalance between water supply and demand constitutes a severe challenge for the smooth implementation of “livelihood water resources” which the Ministry of Water Resources initiated.

Challenges and opportunities coexist. To resolve the contradiction between supply and demand is a good chance to establish advanced water resource management concept, promote integrated water resources management and gradually establish a set of effective resources management system and advanced supply-demand management culture.

Domestic and international experiences and lessons indicate that the key points of water resources management should be transformed from traditional water supply management to **modern water demand management** to resolve problems effectively. Demand management re-orientates and augments the demand-oriented model. Various measures are adopted to curb excess demand on water resources and restrict irrational growth so as to achieve balance between supply and demand and ensure economic and social sustainable development.

In pure 'supply side' water resources management, water demand forecasting has a 'free rein' in as much as the supply side must meet whatever demands are forecasts without any constraint being placed on those forecasts.

Rational water demand forecasting is a prerequisite of effective water demand management. The arrangements of water supply projects and demand-supply balance analysis should be in accordance with the results of water demand forecast in water resources planning. If the natural endowment and other constraints (economic, environmental or social) don't allow for the balance of demand and supply, then it needs to develop programmes to make up this gap. While demand management is required to take measures on the demand-side to reduce water demand to narrow or even make up the gap.

Where demand management is being practiced, demand forecasting is more complicated. Demand forecasting has to take account of the potential success of demand management activities that will result in the 'constrained' demand forecast itself.

Therefore, whether the results of demand forecast are rational directly relates to the success of water resources plan and management.

There are many different demand forecasting methods, of varying degrees of sophistication such as single-coefficient methods, multiple coefficient methods and probabilistic methods. Methods used in China, as in many parts of the world, rely on the use of norms or standard water use assumptions for each type of user demand, in conjunction with a combination with forecasts of population growth, urbanisation rates etc. The simplest form is essentially a single coefficient method. Multiple coefficient methods add in considerations such as price elasticities which affect demand and probabilistic methods that allow for the uncertainty in each parameter.

The methods currently applicable in China are outlined in **SL429-2008** – "*Technical specification for the analysis of supply and demand balance of water resources*", with more details given in a national project-level document "*National integrated water resources planning – technical details of water demand prediction*", issued by the Ministry of Water Resources (MWR) in 2004. These original documents should be referred to for the full details. It is understood that **national guidelines on demand forecasting** are under preparation (as at January 2010).

Reference should be made to Thematic Paper 1.8 'Water Demand Forecasting'.

This document introduces the principles, procedures and precautions for the calculation of a water demand forecast. It also summarises practices in accordance with the "*Technical specifications of water supply and demand forecast*" (MWR) (below referred to as "specification") and tries to provide additional supporting advice on the 'Specification'. It aims to enable technical personnel who engage in water resources planning and management to propose a set of unified format, rational and acceptable demand forecast outcomes following the methods and procedures in the guidelines. These outcomes can be as a basis for analysis on water supply and demand balances and also can be as a reference for decision-making.

This document is divided into 2 parts. First it discusses the concept of demand forecast, methods and principles that need to be considered. This part is mainly based on the norms approach provided in "specification". It also introduces some preparatory activities that require to be undertaken before water demand forecast analysis (Sections 2 and 3) can be undertaken; and then it provides the steps of a demand forecast calculation according to a norms approach (Section 4 to 9), these are the main parts; the purpose of this document is also to provide guidance for economic and social aspects of water demand forecasting. It focuses on out of stream water demand i.e. excluding eco-environmental water demand and in-stream demand forecast that is the subject of other documents.

2 Concepts, Methods and Principles

Water demand is affected by social and economic development patterns, water saving levels, water use efficiencies and spatial and temporal distributions as well as the availability of water resources. These impacts are mainly reflected in uncertainties. All water resources planning and management (including system design) need to take full consideration of these factors. Therefore, the influences which these factors bring can be reflected through different demand scenarios, i.e. it needs to develop different demand programmes with different water-saving measures (it is usually presented as different water use norms) for each social and economic development scenario. This is often divided into three sets (high-intensity, moderate-intensity and low intensity projections) or two sets (sufficient water saving and insufficient/no water saving) of demand programmes. So these form many sets of demand forecasts associated with planned social-economic development scenarios.

"Take immediate action: save water"

Therefore, water-saving measures (presented through water use norms), development indicators and water demands are closely related. Water-saving efforts (reduction of water use norms) need to allow for growth and changes in water demand for industry (production) etc. When regional development objectives have been identified, industrial sector have to respond and currently grow (significant increase in production). This will lead to water demand growing sometimes excessively in relation to available resources. This then needs demand-side management to be strengthened, adjusting industrial structures, improving technology, make use of economic measures and adopting other approaches to reduce water use norms, and limiting water demand to a certain range so that these could match local water resources availability scenarios and ensure sustainable development.

The intrinsic relationships between water demand, socio-economic development indicators and water saving measures/efforts (water use norms) indicates that water demand forecasting cannot be studied in isolation. It needs the simultaneous in-depth analysis of socio-economic development indicators and water saving programmes. It is necessary to consider potential water-saving targets and also the requirements for socio-economic development and availability of water resources while setting water demand requirements.

There are several ways to forecast water demand, such as the quota method, the trend method, the product yield methods, per capita integrated water consumption method and the elastic coefficient method. **The current "specification" recommends quota method and trend method, using other methods to validate.** The Quota method has been widely used in water resources planning and management practices across the world. It can be classified as an established method. Only the quota method is described in this document, in compliance with SL429-2008 (MWR).

The Quota method is sometimes called the method of forecasting through indicators (parameters). The indicators/ parameters including values reflecting socio-economic development, ecosystem conservation, environment protection and water use norms of various water users. After these parameters are determined, then it is possible to start to forecast water demands of the various water users. The parameters of water use quotas can be adjusted through growth rates of water demand, structural changes in water demand, per capita water demand and other outputs in turn. Optimising or refining this process until the results meet all the requirements.

Parameters relating to socio-economic development, ecosystem conservation and environment protection are generally subject to the planning outcomes and requirements of authoritative/ government departments or based on the information provided by policy and/or planning documents. The parameters related to water use quota are entirely depends on the collection and analysis of numerous data to calculate the quotas for individual water users in different (planning) zones. The following principles should be followed in this process:

- It should be advanced but also fully take practical viability into account;
- It is necessary to improve water use efficient in the areas with high water use; and incentivise low water use efficient areas to improve water usage as soon as possible to reach an advanced level of water use efficiency;
- It not only requires giving the higher developed water users motivation, but also the situation in less developed areas needs improving to ensure their full interest in the overall water saving society concept;
- It should maximise economic efficiency and maintain the sustainability of ecosystems while reflecting social justice and the protection of vulnerable groups.

3 Preparation of Water Demand Forecast

3.1 Water use category

Firstly, it is necessary to classify water users. Water users can be classified as in-stream water consumption and out-stream water consumption according to location; they can also be classified as domestic water, industry water and eco-environment water consumption based on purpose, where all domestic water belongs to out-stream water use, while there are both out-stream and in-stream water use in industry and eco-environment water. These are the classification used in SL429-2008 (MWR). To clarify:

- **Domestic water** includes rural and urban domestic water;
- **Industry water** includes various types of industrial water use (involving the water within industrial units). ***Primary industry*** (agriculture) water is divided into field irrigation water and forestry, animal husbandry and fishery water; the ***secondary industry*** water is divided into industrial water, which further divided into thermal/ nuclear power industry, high water consumption industry and general industry, and construction water use; ***the third industry*** is basically small industrial units and there is no sub-category. The classification of industry water should be in line with the industry division standard which was developed by ***State Statistics Bureau***. The socio-economic development indicators can be accessed easily and then used to calculate the relevant water use quotas.
- **Eco-environment water** is divided into in-stream eco-environment water and out-stream eco-environment water. Out-stream eco-environment water includes the water used to maintain the eco-environment and/or develop the eco-environment. In-stream eco-environment water is used to maintain the ecological function of river channels and estuaries.

The classification of water users is presented in the following table derived from SL429-2008 (MWR).

The various classifications of water users can be merged or subdivided depending on the requirements of the water demand forecast and the availability of information. It needs to pay attention to avoid duplication and omission.

Industrial water includes the power industry, high water consumption industry and construction water use

Table 1 Water users' classification and hierarchical structure

Water users' classification					Notes
First-level	**Second level**	**Third level**		**Fourth level**	
Out-stream	Domestic	Urban domestic water			Only urban domestic water, not including public water
		Rural domestic water			Only rural domestic water ,not including livestock water
	industry	agriculture	Field irrigation	Paddy field	Rice, etc
				Irrigable land	Wheat, maize, cotton, vegetable, edible oil crop etc
				Vegetables field	Vegetable field
			forestry, animal husbandry and fishery water	Irrigated fruit land	Fruit tree, nursery, economic forest, etc.
				Irrigated pasture	Cultivated pasture, irrigated native pasture, forage reserve, etc.
				livestock	Large and small livestock, poultry
				Fish pond	Fish (reed) pond recharge
		industry		High water consumption industry	Textile, paper making, petrochemical, metallurgy, chemical industry, foods industry
				General industrial	Except high water consumption industry and thermal (nuclear) industry
				Thermal (nuclear) power	Circulating, piston flow
		building industry			Civil engineering construction, pipeline and equipment, Building installation, buildings fitting and decoration
		Tertiary industry			Tertiary industry water and consumption for fire and special use, etc.
	environment	Urban environment			Green belt sprinkling, replenishment of urban rivers and lakes, sanitary, etc.
		Rural environment			Replenishment of lakes and wetlands, vegetation construction, groundwater recharge
In-stream	industry	hydropower			hydropower industry
		navigation			Inland river and inland lake navigation
		aquiculture			Freshwater aquiculture(except fish pond) other water requirements are considering in in-stream environment water
		others			Drift wood, tourism, etc.
	environment	Maintain river channels' function			Ecological base flows, sediment transport, aquatic biota, etc.
		Estuary environment			Scouring silt in the harbor, proof salt tide, estuarine organism

3.2 Subdivision of water demand forecast calculation

It is often common to take a combination of water resources zones and administrative divisions to provide the spatial unit for a water demand forecast calculation. Socio-economic indicators are collated according to administrative divisions, while the temporal and spatial distribution of water resources is based on river basin or smaller hydrological unit.

Water demand forecasts are related to the current and projected socio-economic development and also related to water resources development.

Water demand forecast zones can be also identified according to the water resources zones which were used to undertake national or provincial integrated water resources and other water related plans. Smaller zones are adopted for water demand forecasting where water resources are scarce or there are obvious contradictions or conflicts between water supply and demand.

3.3 Horizon year

Demand forecast horizon years include base year (status level year) and possible planning horizon year(s).

The base year should have the full range of information, be representative and close to reality.

Planning horizon years includes short term horizon year, medium-term horizon year and long term horizon year. The short term horizon year is 10~15 year from the base year, 20~30 or even longer is medium-term horizon year/ long term horizon year.

The planning horizon should be the year when regional or industrial development goals should be achieved and should be based on certain objectives such as regional and national economy and social five year development plans as well as its long range objectives in the context of the economic sectors' development plan. The water demand forecasting horizon(s) needs to be linked to the economic planning horizon(s).

Water demand estimates in the base year and forecasts for the planning horizon should be carried out for normal flow year (P=50% or normal value of accumulated year), medium dry year (P=75%) or extraordinary dry year (P=90% or P=95%) according to the 'forecast use' requirements and other specific conditions.

3.4 Data collection

Water demand forecasting needs a large amount of data, including:

(1) Statistics related to socio-economic development are mainly from statistical yearbooks.

Social indicators include: changes in population size and distribution, urbanization rate and the status of urban and rural development.

Economic indicators include: economic growth rate and scale, output values, added values and industrial structures etc. Main indicators are regional GDP and its growth rate, ratio of GDP by type of industry, industrial added values, agricultural acreages, cultivation areas, agricultural irrigated areas, grain yields and livestock inventories, etc.

(2) Water use status information is mainly obtained from official water resources bulletins and other statistics and reports, such as information on domestic water, industrial water and comprehensive water consumption.

Information on domestic water includes: urban domestic water consumption, rural domestic water consumption and their changes or trends.

Information on industrial water use includes: gross industrial water use (including losses), thermal (nuclear) power water, high water consumption industrial water and general industrial water), field irrigation water, water consumption of forestry, animal husbandry and fishery, recycling rate of water used by industries, utilization coefficient of irrigation water, water consumption for construction and tertiary industry, leakage rate of urban water supply networks and changes in other items.

Ecological water consumption includes out-stream and in-stream water and environmental water as well as their changes.

Other water consumption information includes per capita (unit output value or added value) comprehensive water consumption, utilization rate of surface water, abstraction rate of shallow groundwater, water resources consumption rate and their changes in recent years.

(3) The main sources of information on the objectives of development plans are social and economic development plans, land improvement plans, ecological restoration and rehabilitation and environmental protection plans, e.g. five-year or long term plans of national economic and social development prepared by governments at all levels, as well as departmental or industrial development plans. It is also very important to collect relevant study reports, plan documents and other outputs from different sectors involved in water use.

3.5 Water demand (use) in base year

Water demand forecast is based on estimates of the utilisation of water resources. The process needs to identify water demand and quota in base year before forecasting the water demand in planning horizon year. Then it is necessary to estimate rational water quotas and water demands for each kind of water user based on current actual water consumption considering two aspects. There may be shortage of water supply and full water demands can not be met. In most situations it is required that the shortfall need to be met; on the other hand, water supply can be excessive such that some water users consume more water than their real needs. Any excess supply needs to be reduced accordingly.

However, the issue or adoption of **demand management practices** needs also to be accounted for, such that the ‘current demand and/or use levels of all water users is questioned.

4 Socio-economic Development Indicators

Socio-economic development indicators and parameters which relate to water demand forecasting include: population and urbanization rate, national economic development indictors, agricultural development indicators and land use indicators, etc. Other departments’ forecast outcomes or information they provide are often used as the indicators. It needs to be noted that all indicators should be co-ordinated (correspond) with other national and regional development indicators. Stakeholder consultation is essential.

4.1 Population growth and urbanization

Population forecasts should include the following: total population, urban population, rural population and urbanization rate. Statistical criteria are to be based on the permanent population not the transient. Population forecasts can be obtained by making use of the outcome of population development projections and planning or through population growth models / indexing method with the information provided by birth control departments, statistics departments and macro-economic regulatory departments.

Population growth rate is the algebraic sum of natural growth rate and the growth rate linked to population movements. With the rapid development of urbanisation the forecasting should pay particular attention to population migration between rural and urban areas.

Urbanisation forecasts need to tie in to urbanisation development strategies and plans prepared at national level and governments at lower administrative levels. Ideally, induced urbanisation should give full attention to water resources' carrying capacity of the urban development and also arrange the layout of towns rationally based on the size of the future urban population. Urban population can be forecast by using official urbanization rate projections.

The future population to be served could be forecast on the basis of urban and rural population forecasts. The Urban population served with water refers to the population connected to the urban water supply networks and the population of enterprises and public institutions which have their own water sources.

Rural water serviced population means the population connected to rural water supply systems (including self-supplied).

Domestic water of the transient population is categorised under tertiary industry.

4.2 Economic development

National economic development indicators include regional GDP and its componential structure, added value/ gross product and it's growth rate. The statistics and forecasts of all economic indicators should be under a common pricing system.

While determining the goals of national economic development, it must take characteristics of local economy and resources into account and make use of related existing outcomes as far as possible. In addition to the indicators of gross development, it also needs to forecast the development of major industries and correlate the relationship between sub-sector indicators and gross indicators. The indicators also could be forecast based on the information provided by macro-economic regulatory departments, departments in charge of overall economic management and socio-economic information statistic departments in the absence of national economy and social development plan and other outcomes of sector/ subject plans.

Since the Statistical Yearbooks are now gradually tending to use added value, taking the place of gross product. Hence, it is better to use the 'added value' as a major indicator for the demand forecasting of each industrial development and make gross product as a supplement. Macro-economic models could also be used to assist forecasting.

If only out-stream water demand needs to be forecast, then it is not necessary to aggregate and forecast the water used for hydropower, navigation, aquaculture, etc which mainly depends on in-stream water.

Due to great differences in water consumption values and the way water is used, there is a need to forecast industrial economic development indicators for thermal (nuclear) power, high water consumption industries and general industries separately.

Industrial added value (product value), installed capacity and electricity generated can be used for forecasting the development of thermal (nuclear) power, considering the different cooling modes of generator systems.

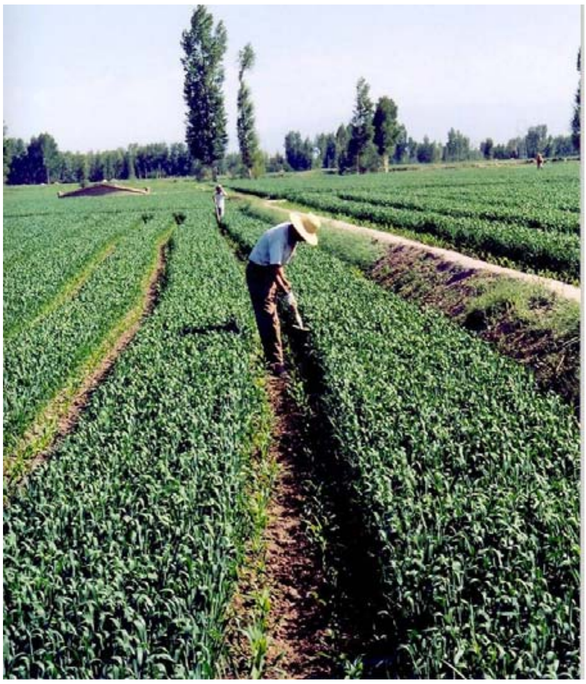
Added values for developed residential areas and per capita completed residential areas can be used as indicators for construction industry changes in demand.

Except for ‘added value’, other indicators such as number of employed persons and per capita added value could be used as forecast indicators for tertiary industry.

(It is worth noting that if in-stream water has been included in the calculation, this part should be deducted to avoid double counting).

4.3 Agriculture development and land use

Agriculture development and land use indicators include: irrigated areas of farmland, forest and fruit trees and pasture; areas of fish (reed) pond; livestock inventories etc are used as indicators. These also include agricultural acreage, cultivation areas of main crops (grain), the added value of agriculture (output value) and grain yields where necessary.



Agriculture development and land use should be included within water demand forecasting

Indicators of land use can be directly from the overall plan for land utilisation or be based on the information provided by administrative departments in charge of land, agriculture and water resources.

Forecasting agricultural acreage should follow the regulations/laws/policies on land management and converting farmland to forest/ pasture/lake with considering the affects of infrastructure construction, industrialisation and urbanisation.

The forecast of irrigation areas is based on the statistical data from water administration authorities with reference to farmland irrigation plans everywhere else and making necessary adjustments.

The local water availability and climatic conditions as well as market demands should be taken into full account while using farmland irrigated area indicators. There could be a need to adjust cropping patterns and identify appropriate sizes and layout for paddy field increase, irrigable land and vegetable land changes. Irrigation areas can also be classified according to specific crops or broken down into well irrigation, canal irrigation, or a combination of wells and canal irrigated area according to the water source (conjunctive use).

The areas of irrigated pasture and the numbers of livestock could be forecast after considering the development of animal husbandry and the balance between livestock and pasture according to the animal husbandry development plans and the demand for livestock.

The areas of irrigated forestry and fruit tree land can be forecast based on the forestry and fruit industry plans and market demands. The areas of shelter forest for farmland in arid and semi-arid area are incorporated in irrigated forestry and fruit trees category. Areas are usually as development indicators for fish (reed) pond according to the plan from the relevant departments.

5 Socio-economic Water Demand Forecast

5.1 Domestic water demand

Per capita water consumption per day (litres/capita/day) is used for domestic water demand forecasting.

Urban and rural domestic water quotas, at appropriate economic development level and living standards can be estimated in relation to the outcome of social development forecasts and combined with availability of water resources.

These water use quotas need to be based on investigations of current urban water consumption and water saving levels referring to the trends and increase in the water use processes of urban domestic water both at home and abroad. This needs to with consider water use practices, income levels, water price levels and the use of water saving appliances.

Water use quotas need to be based on current urban water consumption and water saving levels

The most important need for urban domestic water quotas is to formulate water quotas at different planning horizons based on socio-economic development levels and living standards in the future. The improvement of living standards will lead to the increase in water demand, although improvements in water saving activity and technology will reduce water quotas. The effects of these two factors need to be carefully considered.

Rural domestic water quotas past and future

The determination of rural domestic water use quotas is based on the past and current water use quotas and their trends with considering the development of the rural economy, the improvements of living standards and water supply and the promotion of water saving measures. These factors need to be considered in forecasting the different water quotas in planning horizon year(s).

It is necessary to forecast both net and gross domestic water demands for urban and rural residents respectively.

There are not large variations in water demands through the year, so that yearly water demand can normally be determined based on monthly averaged water demand during a year. If there are indeed large seasonal variations, then it is necessary in some forecasting requirements to identify the distributional weighting for each month and then to determine the water demand requirement within a year.

The trends of urban domestic water use quota and water demand in the future.

Statistics show that along with economic development and improvement of living standard, the current domestic water use quota has improved considerably although, generally speaking, living standards in China are far removed from those of developed countries at present. However, domestic water quotas for urban residents are predicted to continue to rise in the foreseeable future.

With urbanisation taking place, not only will the absolute size of the urban population increase but also its proportion of the total population will continue to increase. With the increasing water use quota, it is expected that the absolute quantity of domestic water demand for urban residents and the proportion of total water demand that this comprises will continue to gradually increase.

The trends of rural domestic water use quotas and water demand in the future.

As for the urban domestic water use quota, domestic water use quota for rural residents also shows an upward trend. Due to various constraints, domestic water use quota for rural residents is generally much lower that urban residents. With the shrinking difference between urban and rural areas, the increase of rural domestic water use quota is expected to increase at a rate greater than the increases in the quota for urban residents.

As a result of urbanization, there has been a steady population shift from rural to urban areas. The proportion of rural population is bound to decline year by year in many rural areas. However, the depopulation or out-migration rate is different between different areas. The sum of natural growth rate and any induced in-migration rate (generally negative, this means out-migration) can't be generalized as a positive or negative. That is the total rural population can't be always defined as an increase or reduction. Therefore, there is no definite trend for rural domestic water demand as there is for urban regions. It even tends in different directions but this depends on specific local conditions.

5.2 Industrial water demands

Out-stream industrial water demand includes water demand of primary industry (agriculture), secondary industry (industries and construction) and tertiary industry (business and catering industry, and other service industries), so that the categories are in line with normal statistics criteria of socio-economic development indicators as presented in statistical yearbooks.

Primary industry

Primary industry water demand is agricultural water demand, including field irrigation (paddy field, grain, vegetables etc), forestry and fruit trees irrigation (including fruit trees, nurseries and agro-forestry), pasture irrigation (cultivated pasture and forage reserve), fish(reed) pond replenishment, livestock (including poultry) rearing. The Quota method is generally used to forecast these water demands.

(1) Water demands of field irrigation, forestry and fruit trees irrigation and pasture irrigation could be estimated based on net irrigation quota and irrigation water utilisation coefficient. The theoretic crop irrigation norm could also be determined if possible (*see Figure 2*). This requires the definition of the irrigation method etc, considering full/deficit irrigation 'norm' according to the availability of water resources.

There are many researches and practices on crop water demand and irrigation water demand all over the world. Crop water demand at different growth stages can be calculated theoretically according to relevant meteorological data and crop coefficients. Water deficit in natural condition could be estimated through effective rainfall and soil moisture utilisation during the growth stage. With extra water allowances for leaching, 'storage irrigation' (soil profile saturation) (which also could kill the over-wintering pests) and fertilizer irrigation, then the crops requirements for irrigation can be estimated. Finally, one needs to consider the constraints, such as the relationship between crop yields and water, water availability etc thereby deficit irrigation norms can be formulated.

In addition, some relevant departments and research organisations have got useful experience and information from numerous irrigation experiments that can help in the demand forecasting process. This information can also be used as a basis for determining the irrigation quota. The 'integrated (composite) net irrigation norm' could be obtained through sum the net irrigation norm of different crops with weighting for representative cropping patterns in particular zones or areas (such cropping patterns can be derived from agricultural statistics).

If the conditions are not allowed to directly determine field integrated net irrigation norm, then it needs to consider the composition of crops, climatic conditions, irrigation system, multiple crop index and other factors. Firstly there is a need to calculate net irrigation demand using the forecasting of irrigated areas, then to calculate the gross irrigation demand combined with field water utilisation coefficient (field application efficiency) and canal water delivery efficiency. The irrigation water use efficiency should be in accordance with water saving plans in the irrigation district (ID) and should allow for the differences between different IDs and the effects of water saving measures introduce and to be introduced.

Irrigation water demand under different precipitation frequencies can be forecasted as needed. The irrigation norms relate to the following precipitation probabilities: P=50%, P=75% and P=95 % (or P=90%). These can be used to represent the irrigation norms in the horizon or forecast year, being an average year, a moderately dry year and an extremely dry year. A long series of precipitation data should be used for this calculation.

The specific methods and procedures on how to determine 'irrigation norm' can be found in relevant documents and literature, see Advisory Note 1.8/2 'Agricultural Water Use Norms'.

Irrigation water is seasonal and distributed non-uniformly, which makes it necessary to consider crop composition and the requirements in different growth stages, irrigation practices, distribution of precipitation and other factors to propose monthly irrigation demands for a particular forecast need.

Primary industry water demand is agricultural water demand

The procedures of forecasting irrigation demand for field, forestry and fruits land and pasture are basically same.

The trend of irrigation water use norm and water demand

For various reasons, the country's water supply situation is becoming increasingly problematic. As the largest water users, water saving in irrigated agriculture, which accounts for nearly two-thirds of the total water consumption of the whole country, receives a wide level of concern/ interest.

As the promotion of various water saving irrigation techniques is undertaken and detailed research is undertaken of deficit irrigation, crop irrigation norms should be reduced. This is expected to be the case especially with the restructuring of cropping patterns the use of 'integrated irrigation norms' has declined in recent years. Therefore, while the irrigated areas in the whole country are increasing gradually every year, agricultural water consumption maintains steady. The use of 'integrated irrigation norms' is expected to decline continually, however, water demands for irrigation are expected to remain steady with a declining trend for the proportion of irrigation water demands to total water demands that will last for a long period into the future if current plans are followed through.

In terms of the irrigation sector, since eco-environmental issues are receiving more and more attention and the polices of converting cultivated land to forestry/pasture are being carried out, the areas of forestry/ fruit land and pasture, which are considered to be more ecological beneficial, will continue to expand The growth will also be greater than for any growth in field irrigated area. This trend will be more significant in the northwest where there are more areas suitable for forestry and pasture that are also located in a more vulnerable ecological environment. Thus, the percentage of irrigation water demands for forestry/ fruits land/ pasture will increase to some degree, depending on local conditions.

(2) Water demand for livestock (including poultry). This refers to livestock (including poultry). Livestock water requirement refers to the amount of water needs for cultivating livestock, including drinking water, bathing, barn cleaning and other uses.

Water norms for livestock are often classified by 'big' livestock, small livestock and poultry to categorise norms. Alternatively, a conversion from meat output to number of head of livestock can be used to calculate water demands. If conditions permit, water use norms can be calculated in accordance with the specific types of livestock to.

Trends in livestock water demand should be accounted for

Water demand norms are different for livestock under different conditions (free range, farm raised, and house raised (enclosed/ semi-enclosed)). On the other hand, water demand norms could differ greatly if the livestock type is different even when conditions are similar. Therefore, livestock water demands need to consider both the farming conditions and the livestock mix. (*Compared to irrigation water demands, these demands are normally small and are generally of local interest rather than regional – however they can have a large localised impact with intensive livestock holdings*).

(3) Water demand of fish pond can be estimated according to the areas of fish pond and replenishment quotas. Replenishment (water recharge or replenishment requirements per unit area of pond) depends on precipitation, evaporation from water surface, leakage from the base of the fish pond and the times of water refreshing. The determination procedures of replenishment norms for fish ponds in demand forecast horizon year are normally the same as in the base year. (*Compared to irrigation water demands, these demands are normally small and are generally of local interest rather than regional*).

The forecasting procedures of water use norms for productive reed field are similar to those for fish ponds.

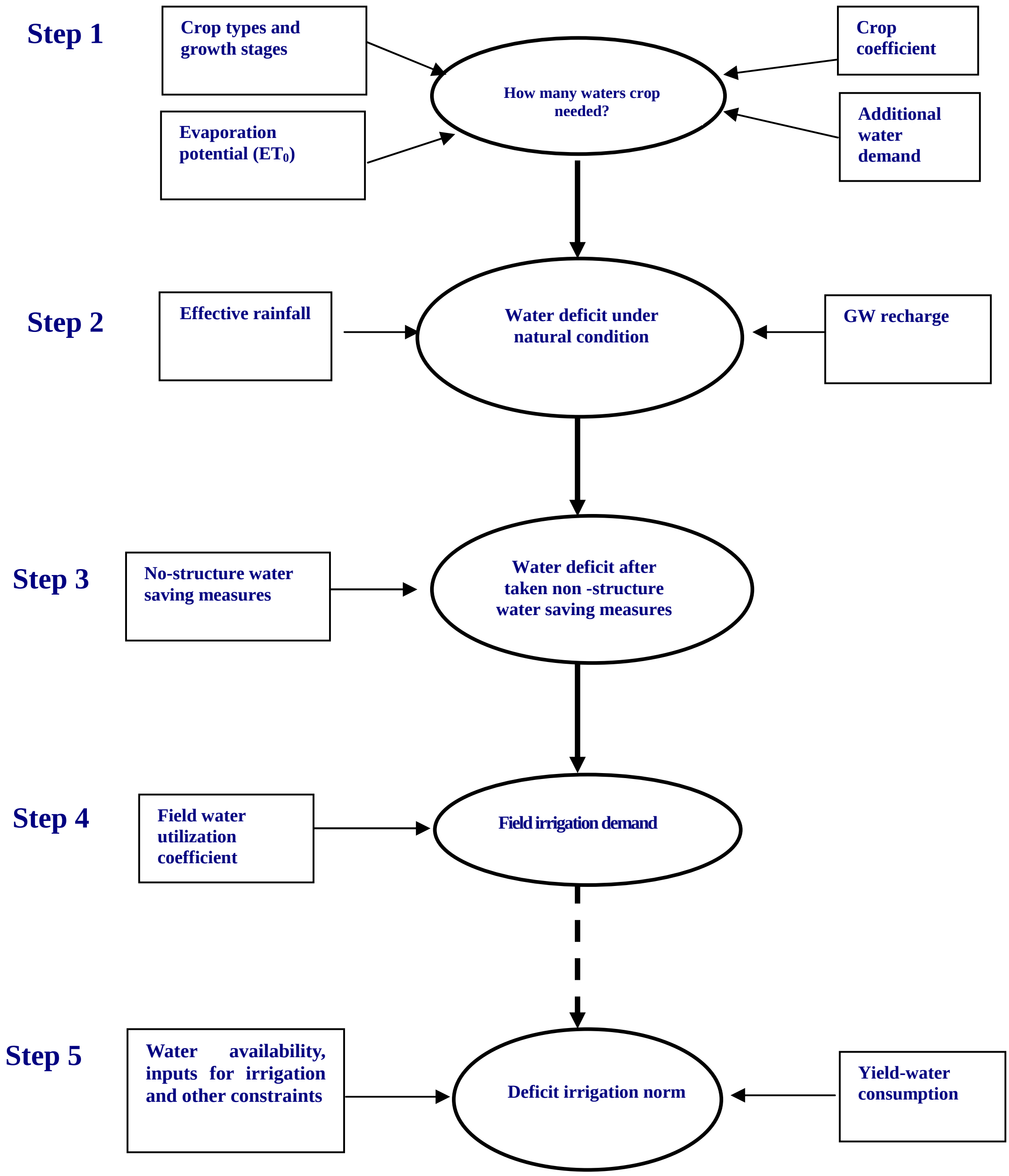
The trends of water use norm and water demand for livestock breeding and fish pond recharge:

Water demand norms for livestock are expected to show an upward trend in the foreseeable future. This is mainly to take into account of the fact that many parts of the country have been over-grazed. The scale of free range farming is expected to shrink whilst more intensive livestock rearing should grow. Improving breeding conditions and animal welfare should therefore increase water demand norms, but this increase should not be too great.

As the country is progressing towards a more affluent society and started to achieve the goal of being a 'moderately developed country', the demands for animal products are expected to increase significantly. This will require a more substantial increase in activity of the livestock industry and lead to an expected growth in livestock water demand as livestock populations increase. The distribution of water demand for livestock in the future will vary between regions as a result of differences in the planned industry structure.

Output of aquaculture products is also expected to expand to meet the growing demand of protein intake of the more affluent society. This will lead to an increase in water demand for aquaculture throughout the whole country in the future.

Figure 1 Determination of irrigation norms



Secondary industry

Out-stream secondary industry water demand includes industrial water demand and water demand of the construction sector.

(1) Industrial water demands are forecast as thermal (nuclear) power, high water consumption industry and general industry. These could be broken down if necessary into sub-sectors. Besides the standard norm method for forecasting, secondary industry also requires the consideration of the trend method, reuse coefficient factors and price elasticity coefficient methods. There are other methods also sometimes used, including the component method for large industrial water demands.

The water demand per 10^4 RMB added values is commonly used as an indicator to forecast water demand of high water consumption industry and general industry. There are two different ways used for estimating demands for cooling water in thermal (nuclear) power, i.e. recycling cooling water and once-through cooling water. The following indicators can be employed: water required / consumption per unit of electrical power generated, water required/ consumption per installed generation capacity or water required/ consumption per unit output (added value). Any of these can be used for water demand forecasting. Abstraction and water use/ consumption should be forecasted separately for clarity.

Reference may be made to industrial water use norms developed by relevant departments and provinces (autonomous regions and municipalities) and the existing industry water use norms in developed and advanced countries/regions taking into account local conditions. (Refer to Thematic Paper 1.8 'Water Demand Forecasting'.)

All factors should be fully considered while forecasting industrial water use norms, including: (1) industry type and product mix; (2) water consumption and water saving characteristics; (3) production scale; (4) manufacturing and processing techniques, equipments and state of art technology (Best available technology); and (5) water management practices; and (6) water price and associated elasticity.

The determination of water use norms for each industry in forecasting horizon year should take the present water source, water supply system and use characteristics into account and also consider the possible outcomes of water supply plans and water saving plans on future demand.

The allocation of industrial water use is relatively uniform through the year. If there is variation in use/ consumption profile, then there will sometimes be a need to estimate the monthly allocation coefficients though an investigation of the water demands during the year.

(2) Water demand of building (construction) industry can be forecast using indicators such as the urban per capita water consumption, or water consumption per building area per 10^4 RMB GDP (added value). Water use norms for the building industry should be developed for various forecast horizon years based on the trend analysis of water consumption indicators considering local conditions and economic development in the future. Thus water demands can be forecast.

Water use coefficients for the building industry sector could refer to the domestic water supply system and then forecast gross water demand accordingly. (Urban population growth will dictate or be a proxy for construction industry water demand trends).

The allocation of industrial water use is normally relatively uniform during the year. If there is greater variation, then it needs to estimate the monthly allocation coefficient though typical investigation to identify the water demands process during the year.

The trends of water use norm and water demand for secondary industry (industry and building industry).

Industrial water use norms have been declining steadily for a long time in line with government policy and initiatives. Due to the increasing water stress, this downward trend becomes more pronounced especially in recent years. Accompanying technological developments, improvement of techniques and strengthened management, water use norms related to a number of industrial products will continue to decline. Along with the implementation of energy-saving and emission reduction policies, the development of water-saving society and the adjustment of the internal industrial structure, this downward trend is expected to last for a long time.

As the general industrialisation level in the country is far from its peak in terms of industrial economy, whether as the absolute amount or the percentage of total national economy, it is expected (or planned) continue to increase at high rate with for the foresee future. Although the industrial water use norms will be declining, the overall industrial water demand is expected to increase.

The trend of the building (construction) industry is similar to other industries and is linked to industrial growth and urbanisation. Although the 'integrated' or composite water use norm will decrease with the improvement in water saving, both the absolute amount and relative amount of water demand in the construction industry is expected to grow. Since water consumption in the building industry accounts for a small proportion of total water consumption, any unexpected growth in construction will not affect overall water use requirements significantly.

Tertiary industry

Tertiary industry is mainly located in urban areas. While applying the quota method to forecast water demand, various approaches are possible: urban water consumption per capita (use of urban population as an indicator of the size of tertiary industry), water consumption per 10^4 RMB added value or the specific industry type water consumption per capita of the industry employees could be used as indicators. Tertiary industry covers numerous sub-sectors. Water consumption of each sub-sector can be quite different to each other. While developing water use norms, there is a need to give full consideration to its composition.

Water utilization coefficient of tertiary industry and the allocation process should refer to approach for the urban domestic water demand forecast.

The expected growth in tertiary industry and trends of water use norm and water demand

The complicated structure or heterogeneity of tertiary industry implies that integrated or composite water use norms can differ greatly between regions whilst the trends of water use norms (decreasing or increasing) are less clearly defined for a particular planning or forecast horizon. There is a need to analyse the water use norms under the existing structure or mix of tertiary industry in a region and relate this to the national/ regional policies and tertiary industrial development plans, considering local conditions to identify the changes (decreases or increases) of integrated or composite water use norms to apply to the tertiary industry at each horizon.

Current National industrial development policy gives priority to tertiary industries. The growth in tertiary industry has been significantly greater than other industries in the whole country since introduction of the reform and "opening-up" policies. However, the base of tertiary industry is weak. The proportion of tertiary industry in the total national economy is still at a lower level compared with developed countries or even to some developing countries. Tertiary industry still has great potential to develop. It is expected that the growth rate of tertiary industry will continue to be higher than for primary industry and secondary industry if the national industry development policies are followed and tertiary industry is given high priority. The adoption of the industry development plan will enable the country to leap into the post-industrial era.

The growth rate of tertiary industry is expected to be much higher than other industries, which may lead to a corresponding significant growth rate in water demand for the sector. Relatively speaking, the tertiary industry has relatively high potential for energy-saving and water-saving, if adjustments are made to the internal structure of tertiary to promote water-saving further, then it is also possible that the growth of water demand in tertiary industry will not be very severe. However, it will depend on the local specific situations.

Tertiary industry is still relatively small in terms of GDP and water demands compared to other sectors. Tertiary industry currently consumes less water (be it measured as an absolute amount or a relative amount) than other major water users. Whether the changes of water use norms and water demand of tertiary industry is severe or not, it will not have significant impacts on the general water demand pattern in the short term. It should be noted that tertiary industry is basically concentrated in urban areas. It will affect the tendency of water demand structure in urban areas where tertiary industry is relatively well developed and in large cities there will be significant impacts.

According to statistics, public water supply has exceeded domestic water in some cities (mainly large cities) at present. One needs to refer to these trends while estimating the growth of water demand for tertiary industry in forecast horizon year.

It should be pointed out that tertiary industry is normally supplied with water by a water supply company in the same service delivery system as domestic demands.

5.3 In-stream water demand

In-stream 'production' water demand includes navigation, hydropower, fresh water aquaculture, tourism, leisure/ recreation and other water needs. *[Note the term 'production' is used to differentiate the assessment from 'ecological' needs].*

In-stream 'production' almost never 'consumes' water, the requirement is normally a certain depth of flow and sometimes a minimum flow rate. To forecast various production water demands should be in accordance with their respective characteristics and requirements and refer to a relevant calculation or assessment method.

In-stream production water demand and in-stream eco-environmental water demand should be considered together.

6 Eco-environmental Water Demand Forecast

Eco-environmental water refers to the water needed to maintain and protect ecosystem and environment and can sometimes also include the water required for ecological re-construction and environmental improvement.

Firstly, it is necessary to prepare the goals for environmental protection and restoration by the forecast or planning horizon year according to the overall plan for socio-economic development and environmental construction. This together with a knowledge of local conditions then should enable a forecast to be made of water demands on the basis of these environmental goals.

Eco-environmental water demand is classified as in-stream eco-environmental water demand together with out-stream environment eco-environmental water demand.

Out-stream eco-environmental water demand refers to the water supplied or diverted to meet the needs of environmental protection, restoration and ‘construction’. It can be further divided into (a) urban eco-environmental water demand (including the needs of urbanised channels and lakes, green water (landscaping), sanitation water (cleaning or flushing), etc.) and (b) rural eco-environmental water demand (including controlled ground water recharge and supplies to shelter forest/ grass lands, etc.).

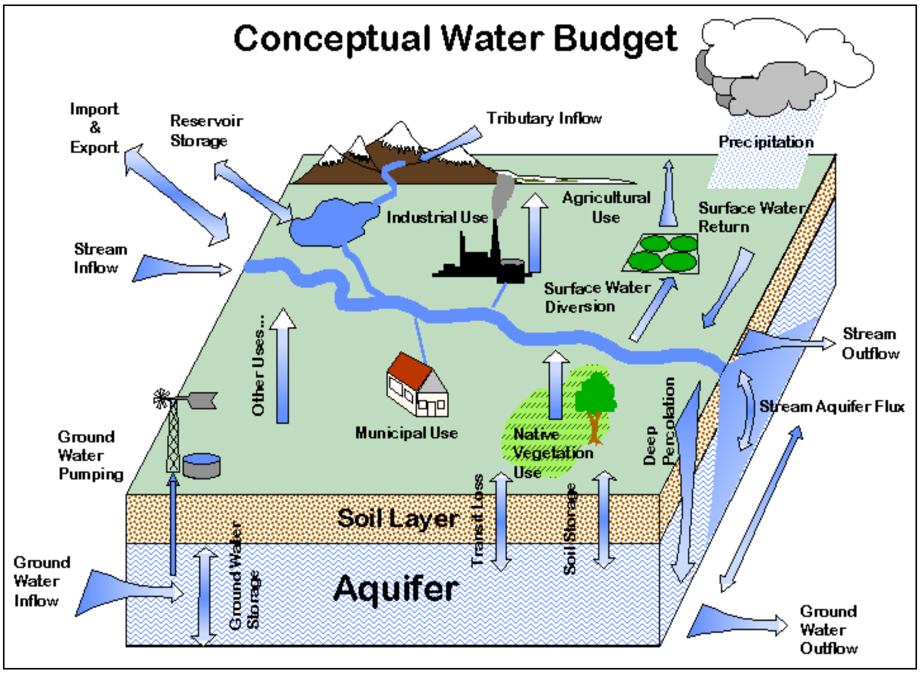
In-stream eco-environment water demand means the water (flow) retained to maintain the shape of river system and the function of the aquatic ecosystem. It could be classified as four elements according to the requirements of environment: ecological base flow, the minimum eco-environmental water demand, eco-environmental water demand to meet special requirements of eco-environment system and total eco-environmental water demand. According to the purpose, it could be divided into water demand to maintain the river's basic functions (including the prevention of a river from drying up, the maintenance of a certain dilution and self-purification capacity, the requirement to flush sand and sediment and also maintain the survival of aquatic organisms). Supplies are also required to meet water demand of lakes wetlands which are linked with the rivers (including water demands of lakes and swamp or wetland areas), estuary environment water demand (including scouring of silt in harbours, the control of saline intrusion and the needs of estuarine organisms).

The forecasting of out-stream eco-environmental water demand and the determination of artificially recharge requirements should be based on the objectives and requirements of eco-environmental maintenance and restoration in the planning horizon year and the base year with considering the local conditions of water resources.

For urban greening (landscaping) and shelter forest/grass, reference should be made to the methods for forecasting agricultural water demand and use the quota method to forecast the associated water demand. (See Advisory Note 1.8/2 'Agricultural Water Use Norms'.) Greening or urban landscaping could be based on a water per capita indicator to forecast urban greening water demands (an estimate of the area of land to be landscaped, as per existing areas and areas defined by plans or an area as a percentage of the urban land area can provide a suitable basis).

For the recharge or replenishment of rivers/lakes and wetlands, this can be estimated by calculating water consumed through analysing evaporation and leakage loss per surface area and then to determine a 'recharge or replenishment' norm according to the proposed areas considering the water needed to maintain water quality. An estimate based on local feedback and knowledge would also be an approach being checked by the 'norm' approach.

In-stream eco-environmental water is often expressed as the percentage of average flow which is needed to be retained within streams and rivers. In-stream eco-environmental water belongs to non-consumptive water. There are a many calculation methods available for this purpose depending on the specific conditions although a modified Tennant method is mentioned in document SL429-2008 (MWR, 2004). Reference should be made to "*Environmental impact assessment of river basin plan*" (SL45-2006) and "*Guidelines for Assessment of Ecological Water Requirements*" and other relevant literatures could be referenced.



Eco-environmental water demand includes the water necessary to protect and maintain ecosystems and the surrounding environment

7 Aggregation of Water Demands

Owing to the different nature of water use in different sectors and situations, water demands should be aggregated according to in-stream water demand and out-stream water demand respectively.

The aggregation of out-stream water demand is based on water demands of domestic, industrial (including agriculture as primary industry) in-stream 'production' and eco-environment requirements at different time horizons as per the forecast requirements. This can be done for different forecasting methods and assumptions. Water demands can also be aggregated according to urban and rural areas or urban development planning zones or administrative districts.

Water 'consumption' for in-stream is usually nil unless conditions are such that river bed infiltration losses need to be allowed for and evaporative losses from large lake areas. The same water body is shared by the 'production' water 'users'. Water used in the upper reaches of a stream would normally be assumed to be reused in downstream reaches as long as river bed seepage and outflows to groundwater are not an issue. The integrated or composite in-stream water demand can be obtained by considering the 'enveloped' values for the different uses and in the different periods (e.g. monthly) i.e. for each item of in-stream production water demand and eco-environment water demand. In-stream water demand is not included in out-stream water demand and supply equilibrium analysis, while but it is required to combine or link water use in-stream and out-stream to allocate regional water regional water resources appropriately.

8 Requirements Summary

Water demand for all abstractions - agricultural water demand, industrial water demand, the construction industry and the tertiary industry water – in addition to domestic demand are covered by the MWR 2004 document **SL429-2008 (MWR)** which provides tables wherein the following characteristics are to be completed for a province, autonomous region or municipality under the central government:

- population development indicators *(urban and rural populations, urbanisation ratio and the percentage of populations with piped water in urban and rural areas)*;
- main economic indicators for different sectors in the national economics *(covering the agriculture sector, high water consuming industry, other industry, thermo(nuclear) facilities)*.
- indicators for agricultural development and land utilization *(arable areas, irrigated areas defined as areas of paddy rice, vegetables, horticulture with additional information on aquaculture and livestock numbers)*.
- indicators for irrigated areas by different irrigation type *(for irrigation by surface water, groundwater, conjunctive use the areas of overall irrigation and paddy rice, vegetables, horticulture served by each)*.
- indicators for socio-economic development in urban districts

(by industrial category and defined primarily as added values).

- domestic water demands forecast *(based on population in urban and rural areas together with l/c/day norms and water use efficiency assumptions to yield gross water volumes at each annual time horizon)*.
- water demand forecast for farmland irrigation for two scenarios (base and recommended). *(irrigation norms (m^3/mu) for paddy rice, other (grain), vegetables, horticulture for various rainfall probabilities (50% (average year), 75% and 90% (1 in 10 dry year)), assumptions for field irrigation efficiency, canal efficiencies at different levels presenting water demands at tertiary level and a gross value each under the different rainfall assumptions);*
- water demand forecast for grassland, forest, husbandry, fishery and livestock for the two scenarios (based on areas, numbers, net norms (m^3/mu or l/c/d), irrigation efficiencies where applicable).
- monthly water distribution coefficients for irrigation.
- monthly water distribution coefficient for forest, husbandry and fisheries.
- industrial water demand forecast for out-of-stream water use *(based on $m^3/10^4$Yuan and $m^3/10^4$Kw type norms).*
- water demand forecast for building industry and tertiary industry *(based on $m^3/10^4$Yuan norms for building industry and tertiary industry plus allowances for delivery efficiencies).*
- summary of urban and rural net water demand forecast as net and gross values *(incorporating the rainfall probability categories carried through from the irrigation demand forecast determination).*
- eco-environment water demand forecast for main in-stream control nodes *(based on mean monthly flows, environmental flow as a % of this value grossed up into an annual volume. Other allowances are given for flushing, prevention of sea water intrusion and for ecological purposes).*
- eco-environment water demand forecast for towns and cities *(estimates for urban landscaping, sustaining urban water channels and lakes etc).*
- out-stream eco-environment water demand forecast *(estimates of ecological requirements of off-stream lakes and wetlands, groundwater recharge (artificial) as well as further demands for forests all based on norms of the form m^3/ha, $m^3/m^3 x10^4$).*
- Summary tables for the above.

The tables included in SL429-2008 (MWR) can provide a useful basis for water resource demand forecasting at river basin or municipality level. At municipality level, the tables and supporting calculations and assumptions used at provincial level would be useful in any forecasting the municipality had to undertake. The same tables and supporting information for provinces would also be useful for river basin authorities to review and include in any water resources demand forecasting they would be undertaking.

9 Rational Analysis of Forecast Results

Water demand forecasting relates to various factors and the results are based on many uncertainties whilst the whole process can be quite complex. These uncertainties will increase with the more distant the forecast horizon. Sound data and information, rational and clear analysis together with careful validation are essential. A transparent and systematic process has to be followed with significant reference to plans and basic documents as well as considerable co-operation and consultation with stakeholders.

Method validation: Other water demand forecasting methods should be applied to double check the results of the quota method and then use the comparison to propose a reliable water demand forecast result.

Outcomes validation: the rational analysis of water demand outcomes includes: trend analysis (carry out rational analysis for each indicator's or parameter's trend), structural analysis of the water user or sector in question (coordinate analysis among regions and water users), water use efficiency analysis, water saving indicators analysis, per capita indicators analysis, and comparison with other regions in similar conditions at home and abroad and at similar development stages, coordinate analysis with other relevant plans and research information (investigation and assessment of the utilisation and development of water resources, water saving plans, water supply plans, allocation of water resources, regional development plans, and industrial development plans etc).

The emphasis of the outcome validation should be to ensure a coordinated relationship among socio-economic development indicators and water demand indicators, the availability of water resources, as well as verifying the forecast outcomes' rationality and viability. For example, the growth rate of water demand, changes in the structure of water demand and water demand per capita can be used to calibrate indicators of water demand norms until they meet with various requirements. However, all such adjustments and modifications need to be clearly explained and documented for the understanding of stakeholders and for future reference.

This process of 'rational analysis' is required since the water demand forecast for a particular planning horizon might result in a supply-demand imbalance that cannot be realistically rectified considering the supply options available, this problem being discovered in the water resources planning process. Hence there is the need for the water demand forecasting process to produce different scenarios based on different assumptions. There might be a situation that even with the 'low forecast demand scenario that such demands cannot be met by the resources that can be made available at a particular time horizon, in which case the only recourse would be to revisit the water demand forecasting and review the basic premises of the original water demand forecast, changing indicators and assumptions to enable a sustainable and realistic balance to be achieved. It is appreciated that this is the inherent process of water resources planning but it highlights the vital importance of water demand forecasting as water resources become constrained or limited. The importance and need for water demand management will thus also become more important. This suggested approach provides technical support for decision making after further analysis.

Higher level departments should balance the reported forecast outcomes. For harmonious water forecasts between regions or industries and the existence of impractical outcomes the upper level department(s) should give feedback and explanation of the required revision to the originators of the water demand forecast.

10 Conclusions

This document attempts to explain the conception of water demand forecasting in a simple way and introduce the basics of how to use the quota method to forecast water demand in planning level year. The explanations have been in support of SL429-2008 (MWR) "*Technical specification for the analysis of supply and demand balance of water resources*", and the national project-level document "*National integrated water resources planning – technical details of water demand prediction*", issued by the Ministry of Water Resources (MWR) in 2004. The approach to water demand forecasting is basically a water quota system based on numerous water use norms.

There are in fact a variety of methods that can be used to forecast water demand, each having its own applicability and constraints. (Reference should be made to Thematic Paper 1.8 'Water Demand Forecasting'). It is recommended to that different methods are used to enable a comparison to be made to lead to a final water demand result.

Water demand forecasting is a fundamental element of water supply and demand equilibrium analysis. This is the basis of water resources planning and management.

Effective water demand management must be based on rational water demand forecast. However, water demand forecasts need to carefully consider all the factors inherent in demand management plans and programmes.

Demand forecasting analysis in water resources management relates to the natural environment, society, the economy and other fields. These are closely linked with water resources development, utilisation, management, allocation, water conservation and protection. Rational analysis must be carried out to ensure reliable results for the water demand forecast. The results of water demand forecast should be coordinated / compatible with economic development plans, land use management plan, ecological 'construction' and environment protection plans, industry development plans and also relate to other factors discussed in the sections above.

It is necessary to ensure that water demand forecasting is undertaken so that there is consistency in approach between sectors and regions. A key aspect of the requirement for rational analysis is to ascertain whether the calculation method and the parameters norms used are appropriate in concept and justifiable and rational in terms of value, reflecting anticipated future conditions. The consultation and coordination with various stakeholders from sector organisations is essential.

For the regions where socio-economic development and water saving development are affected greatly by various uncertain factors, it is better to set several water demand forecast scenarios and then give a range of predicted values. It is necessary to formulate forecasts for different socio-economic development objectives and water saving programs with different levels of estimated impact for the selected forecast horizon. The forecasting process must take into account the plans for investment and activity in water demand management and water saving to ensure a correct reflection is being incorporated of the future water demand - supply equilibrium situation and the associated water allocation situations that are proposed for the future.

Since there may be several future water supply options, the combination of water supply forecast options and water demand forecast situations will produce complicated sets potential future situations when it comes to the water resources planning process. There will be a need to select one or several representative situations as the suggested preference. This would need to be line with the following principles: to meet water demands, water saving (and demand management) targets and to protect environment. In this process it will be necessary to evaluate the effects on and impacts of economic, social, environmental and technical aspects in relation to the forecast options. It will also be necessary to interactively adjust and carry out equilibrium analysis to the water demand forecast and water supply forecast options. This is required to produce a final outcome of the suggested water demand forecast. Hence the need to prepare different water demand forecasts based on different demand side scenarios, particularly related to water demand management. This provides the base material for the water resources planning process.

This process is required since the water demand forecast for a particular planning horizon might result in a supply-demand imbalance that cannot be realistically rectified considering the supply options available. The only recourse would be to review the basic premises of the water demand forecast, changing indicators and assumptions to enable a sustainable and realistic balance to be achieved. Clearly this relates to both surface water sources and groundwater sources. This is the inherent process of water resources planning but it highlights the vital importance of water demand forecasting as water resources become constrained or limited. The importance and need for water demand management will thus become more important. This suggested approach provides technical support for decision making after further analysis.

Additionally, as resources become more constrained, the accuracy of forecasts becomes more important in ensuring that demands do not exceed supplies, a situation that impacts on the environment, the economy and people.

As the required basic statistical data becomes both more reliable and complete and the calculation methods become increasingly mature, the indicator set (norms) of water demand will gradually be improved and become widely accepted. Water demand forecasting will never describe the future situation at the 100% precision level and give a definite answer to the uncertainties in the forecast estimate. However, water demand forecasting is an essential process for water resource planning and management, especially in relation to water demand management. The results of water demand forecasts are an indispensible reference for policy-makers when making decisions.

Some of the key factors are seen to be:

Water use norms need to be readily available, fully documented and explained with recommendations made as to how to modify the norms for particular circumstances and conditions. Such needs to be more readily available at the national level and for each province. A consistency of approach is required with the method of application of the norm explained and exampled (this is a prerequisite for good demand management practices);

Water loss coefficients can be improved with substantiated estimates from the respective water users (this is also a prerequisite for good demand management practices);

Much data and information is available from different stakeholders. The process of stakeholder consultation needs to b documented and made part of the demand forecasting reporting;

Consumptive use, re-use and return flow estimates, assumptions and information can usefully be incorporated or associated with water demand forecast values;

Stakeholders from different water use sectors should be involved and sometimes (often?) be responsible for the demand forecasts in relation to their plans;

Environmental flows and ecological requirements need to be clearly specified with full documentation.

Flow requirements to ensure adequate absorptive capacity of pollutant discharges need also to be clearly specified with full documentation.

Demand-resource associations are important to define. This can be facilitated through the adoption of a well organised GIS that can also be use for developing demand forecast calculation although the normal methods will probably be through a workbook/ spreadsheet approach that is more accessible to others.

Water abstraction permit data bases should be explored to assist in the development or substantiation of water use norms.

Document Reference Sheet

Glossary:

Eco-environmental water demand	Refers to the water needed to maintain and protect ecosystems and environment
'Production' water demand	Demand assessment that is different from 'ecological' needs
In-stream water demand	Includes navigation, hydropower, fresh water aquaculture, tourism, leisure/ recreation and other water needs
Out-stream water demand	Includes water demand of primary industry (agriculture), secondary industry (industries and construction) and tertiary industry (business and catering industry, and other service industries)

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Document Reference Sheet

Related materials from the MWR IWRM Document Series:

Thematic Paper 1.8	Water Demand Forecasting
Advisory Note 1.8/2	Agricultural Water Use Norms

Where to find more information on IWRM – recommended websites:

Ministry of Water Resources: www.mwr.gov.cn

Global Water Partnership: www.gwpforum.org

WRDMAP Project Website: www.wrdmap.com

China – UK, WRDMAP

1. WRA

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