IRRIGATION AND DRAINAGE
Irrig. and Drain. **62**: 477–487 (2013)
Published online 9 May 2013 in Wiley Online Library (wileyonlinelibrary.com) **DOI**: 10.1002/ird.1735

WATER ABSTRACTION CHARGES AS A WATER MANAGEMENT TOOL†

CHRIS FINNEY*
Independent Water Resources Economist, Lympstone, Devon, United Kingdom

ABSTRACT

This paper reviews international experience with the use of water abstraction charges (WACs) as a tool for water resource management and a means of recovering the costs involved. It is based on a desk study undertaken to derive guidance for the possible improvement of the WAC system in China and for its use as a demand management tool. At present such charges are confined mainly to high- and middle-income countries. Both the existing use of WACs and their levels of charge vary greatly between countries. A key requirement for their successful implementation is a sound system of water abstraction licensing. Once a licensing system is in operation the marginal costs of introducing abstraction charges are low. In most countries the basic aim of WACs is the recovery of the costs of water resource management. Impacts of abstraction charging on water demand were found generally to be small; only where charges are set at very high levels, far above cost recovery levels, are impacts significant. In most countries such high charges are not politically acceptable. A key requirement for the acceptance of WACs by water users is usually the 'earmarking' of the revenue from the charges, so that most is used for water resource-related purposes. Copyright © 2013 John Wiley & Sons, Ltd.

KEY WORDS: water abstraction charges; water resource management; demand management; cost recovery; earmarking of revenues

Received 17 February 2011; Accepted 27 January 2013

RÉSUMÉ

Ce document passe en revue l'expérience internationale traitant de l'utilisation des redevances de prélèvement d'eau (WAC) en tant qu'outil de gestion des ressources hydriques et moyen de récupérer les coûts associés. Il est basé sur une étude documentaire réalisée en vue d'améliorer le système WAC en Chine et pour l'utiliser comme outil de gestion de la demande. À l'heure actuelle ces frais s'appliquent essentiellement dans les pays à revenu élevé et intermédiaire, et les niveaux de charge varient considérablement d'un pays à l'autre. Une condition essentielle pour leur mise en œuvre réussie est un bon système de permis pour le prélèvement de l'eau. Une fois un système de permis en fonctionnement, les coûts marginaux de l'introduction de redevances de prélèvement sont faibles. Dans la plupart des pays, le but fondamental de WAC est le recouvrement des coûts de la gestion des ressources en eau. Les impacts de la tarification du prélèvement sur la demande en eau sont généralement faibles, et seuls des tarifs très élevés, bien au-dessus des seuils de recouvrement des coûts, influent sur la demande. Dans la plupart des pays, ces tarifs élevés ne sont pas politiquement acceptables. Une condition essentielle pour l'acceptation de la WAC par les utilisateurs de l'eau est généralement l'ajustement des revenus aux redevances, et ainsi la plupart de l'eau pourra être utilisée conformément aux usages convenus. Copyright © 2013 John Wiley & Sons, Ltd.

MOTS CLÉS: redevances de prélèvement d'eau; la gestion des ressources en eau; la gestion de la demande; recouvrement des coûts; affectation des recettes

INTRODUCTION

Water scarcity combined with over-exploitation of the available water resources is a major problem threatening the sustainable development of China, especially in parts of northern and western China where the scarcity of water is most acute. The revised Water Law which was approved in October 2002 forms a vital part of the measures being taken to address the country's water resources challenges. Funded largely by the UK Department for International Development (DfID), the Water Resource Demand Management Assistance Project (WRDMAP), a technical assistance project to support the implementation of the Water Law, began operation in 2005 and was completed in 2010. Its main activity was the

* Correspondence to: Mr Chris Finney, Independent consultant, Varnes, Church Road, Lympstone, Devon EX8 5JT, United Kingdom. E-mail: Chrisefinney61@yahoo.co.uk
† Les redevances de prélèvement d'eau comme outil de gestion de l'eau.

application and testing of the integrated water resources management (IWRM) principles and tools introduced in the 2002 Water Law. A British consulting firm, Mott MacDonald, was appointed to help implement the project, in conjunction with the Chinese Ministry of Water Resources.

An IWRM 'tool' given particular attention was the use of economic instruments as a means of influencing water demand and improving the efficiency and productivity of water use. These economic instruments include mainly (i) irrigation service charges and water supply tariffs, and (ii) what can be termed water resource charges, charges made for the use of the water resource itself rather for the provision of the services which exploit the resource. Such charges are commonly referred to as water abstraction charges or, in China, water resource fees. In this paper the former term has been used.

For both water service charges and water abstraction charges a twofold approach was adopted by the WRDMAP, involving a review and analysis of the charging systems and levels currently in use in China and a review of international practice and experience with such systems (Chinese Ministry of Water Resources and Mott MacDonald, 2006; 2007). The objective of the second review was to provide information and guidance for the future development and use of economic instruments for water management purposes in China. It covered two main forms of economic instrument: irrigation service charges (ISCs) and water abstraction charges (WACs).

A major source of data of the first international review, that of ISCs, was a major research project undertaken by HR Wallingford of the UK (HR Wallingford, 2004). It included a very detailed review of literature of experience with ISCs in more than 50 countries, and field studies in four countries (Morocco, Jordan, Macedonia and India). The information available from this source was supplemented by the writer's own experience in countries like Kyrgyzstan, Turkey, India and elsewhere. From the viewpoint of water demand management its main conclusion was that under most circumstances ISCs on government-run irrigation schemes are not an effective demand management instrument. In virtually all countries the prime objective of such ISCs is cost recovery rather than demand management.

This paper presents the results of the second international review, that of experience with the other main instrument, water abstraction charges, which was undertaken for the WRDMAP. The review was a desk study. It covered as many countries as possible but did not include China —a separate review of existing WAC policy and practice in China was carried out by Chinese members of the WRDMAP team.

DATA COLLECTION AND AVAILABILITY

The review was undertaken largely in 2007 and was based on information obtained from: (i) reports and documents from official organisations and other sources such as consulting firms, (ii) the Internet, (iii) email correspondence and other contacts with informed and interested persons in various countries and (iv) staff of the Environment Agency (EA) of England and Wales, especially with regard to the practical and financial aspects of operating a WAC charging system. Very little information on such aspects was found from the other three sources listed above. Despite the considerable efforts made to locate and obtain whatever information was available at that time, it is recognised that the coverage of the study with regard to available data was by no means complete—there were probably valuable data on the subject which were not found in the data search.

The availability of data on the present use and practice of WACs around the world was found to be very variable. Apart from the general lack of data on operational aspects, little information was found on the existing WAC situation in the USA and Australia, for example. Considering that these two countries are often in the forefront of thinking on water resource management, this was surprising.

Before discussing the findings of the WAC review, some important explanations and definitions concerning the role of water abstraction charges and other instruments and measures in water resource management are presented below.

WATER RESOURCE MANAGEMENT AND WATER ABSTRACTION CHARGES

There are three principal measures or management tools available for effective water resource management (OECD, 1996; Rogers *et al*., 1998; 2002):

1. The regulatory ('command and control' (C&C)) approach, involving the control of water abstraction and use through licensing and other forms of control. Such regulation is an essential part of effective water resource management;
2. Economic instruments (EIs). EIs can be defined as the use of prices and charges to raise revenues and/or to motivate desired types of decision-making by water users. When used, EIs are normally part of a larger package involving regulatory and other measures. The two main functions of EIs can be defined as:
   - the incentive function (for behavioural change);
   - the fiscal and financial function (to raise revenue; 'fiscal' if merely to raise revenue for the government budget, 'financial' if the revenue is 'earmarked' for specific purposes such as irrigation system operation and maintenance and water resource management);
3. What are sometimes termed 'suasive instruments' (SIs) or 'soft' measures, which rely on voluntary compliance. Awareness raising is a key part of any SI system.

Water abstraction charges (often termed 'water resource management charges' or, as in China, water resource fees) are a form of economic instrument. They are the charges made by water management authorities (usually government) to licensed water users for the right to abstract water from surface water (SW) or groundwater (GW) sources. WAC charges are based either on the licensed volumes of abstraction, regardless of the volumes actually used, or on actual volumes abstracted, as measured by metering or other means.

WACs can comprise some or all of the following components:

- the administration and other costs of water resource management (WRM);
- the opportunity cost (economic value or scarcity value) of water;
- the environmental value of water (the 'environmental premium');
- the cost of the technical measures (usually, infrastructure developments) undertaken in order to make water more available for abstraction/use, such as dams and storage reservoirs, inter-basin transfers and river training. Unlike the other three components, however, this is not a 'resource charge'. Even though sometimes included as part of an overall WAC charge, it is essentially an infrastructure or service charge. A suitable nomenclature for such charges is the term 'water resource development charges', which is used in South Africa to distinguish such charges from what are termed 'water resource management charges' in that country (Republic of South Africa ,1998; 2006).

In most countries WACs at present take account of only the first component and, in some cases and to a limited extent, the fourth. The charges made normally reflect mainly what might be termed the 'overhead' costs of water resource management and development (i.e. the first component). Such overhead costs cover, for example, the administration and management of the water resource, the control and regulation of its use, and hydrological and hydro-geological data collection and analysis.

A WAC tariff can include the following components:

- an initial charge for being issued with a licence to abstract water; what the UK Environment Agency (EA) terms 'the application charge'. This is usually only a modest amount;
- a basic charge per unit volume, based on either the licensed volume of abstraction or the actual volume of abstraction; what the EA terms 'the annual charge'. In most WAC systems this is the core element of the overall charges;
- various possible adjustment factors to be applied to the basic unit volume charge (the 'charge factors' in the EA system), to take account of various aspects of the water use, including:
- differences between the seasons (e.g. summer and winter) in the availability of surface water resources, with the charge per m^3 being higher in the season(s) of lower water availability;
- the degree of consumptive use of each type of water use, with charges being reduced for those uses with high return flows (e.g. power station cooling water) and increased for those with low or negligible return flows (e.g. spray (sprinkler) and trickle irrigation);
- the quality of the water abstracted; for example, a lower charge for brackish water used for cooling purposes than for fresh water;
- the location of the abstraction; for example, charges may be higher where the pressure on the available water resource is greatest;
- different rates of charge for different categories of water user. For example, agricultural users are often charged a lower WAC rate than other users or are even exempted from charges completely;
- different rates of charge for surface water as compared with groundwater.

WATER RESOURCE CHARGING IN DIFFERENT COUNTRIES

The countries where WACs are used

In general, water abstraction charges are less widely applied than are water pollution charges. At present, WACs are confined largely to high-income and some middle-income countries. Few low-income countries have introduced them as yet although, as water resource availability becomes an increasing problem worldwide, they are likely to be adopted more widely in the future. Major reasons for their rare use in low-income countries include limited administrative and technical capacity and, in some cases, the belief that water is a gift of nature or of God and should therefore not be charged for.

An analysis of 29 OECD (Organisation for Economic Cooperation and Development) countries (OECD, 2005) showed the pollution and water abstraction charge situation for those countries in 2000. At that time 12 countries, including much the largest, the USA, and also Japan, were reported not to apply either pollution or abstraction charges, and 17 applied WACs. Two, South Korea and Sweden, applied pollution charges but not abstraction charges. Most countries in Europe apply WACs, the main exceptions being the Scandinavian countries other than Denmark, Greece, Austria, Switzerland and, probably, Russia.

Elsewhere in the high- and middle-income world they are less widely used. Some US states have now introduced them but, as far as could be ascertained, as of 2006/07, many have not (in the USA, as in Australia, Canada, Brazil and certain other large countries, water resources are largely a state rather than federal responsibility). In the two US examples found, the WACs, which were introduced in 2004, were very low (Internet data). Some, perhaps most, Canadian provinces have WACs (Canada Policy Research Initiative, 2004). Various Latin American countries, such as Colombia and Mexico, apply them and there are three states in Brazil with them (Kraemer *et al*., 2003b). South Africa has a sound and comprehensive WAC system, although its full implementation had been delayed by difficulties in completing the licensing of abstractors in its 19 designated Water Management Areas (South African Department of Water Affairs and Forestry, 2006). The only example found of their application in Australia was in the Australian Capital Territory (essentially, the Canberra area). Strong political resistance had so far prevented their introduction in states such as Queensland.

Different WAC charges for different water user categories

From the water resources viewpoint the most logical approach is to charge all water users the same WAC per m^3 abstracted, provided that due account is taken of the differing degrees of consumptive use between different uses (i.e. their 'loss factors'). On the other hand, this approach takes no account of different user types' payment capacity—the affordability factor. For this reason, in the majority of countries for which relevant information was found there are different charges for different user categories. In particular, charges for agricultural abstractions (usually mainly for irrigation) are often low or even zero. The only clear example found of uniform WAC rates for all users was the United Kingdom (UK) system.

Different water abstraction charges for surface water (SW) and groundwater (GW)

Limited information was found as to which countries apply the same charges to SW as to GW. Where the two resources are hydrologically connected it would seem logical, at least from the water resource management viewpoint, to apply the same WAC rates to both, as is the practice in the UK. Of the other eight (mainly European) countries for which information was obtained, however, only two, Hungary and South Africa, applied the same rates for SW and GW.

The basis for water abstraction charging—licensed abstractions or actual abstractions

Charging on the basis of the actual volumes abstracted is obviously more effective if the primary WAC objective is to influence water demand. On the other hand, it is more expensive, because of the need for reliable data on abstracted volumes and the resultant metering and record keeping. Some countries (e.g. UK, South Africa and Canada) charge on the basis of licensed volumes and others (e.g. Hungary, Italy, Mexico and The Netherlands) charge on the basis of actual abstractions—there is no consistent pattern (ECOTEC *et al*., 2001; Kraemer *et al*., 2003a). If the WAC charging objective is just to recover the budgeted costs of water resource management, there are sound reasons for adopting the simpler and less costly option of basing the charges on licensed volumes.

Water abstraction charge rates in different countries

Table I shows the limited data which were found on WAC rates in different countries, expressed in terms of US$ cents m^{-3}. The original data are from various years in the period from 1998 to 2007.

The table shows the huge range of WAC charges in different countries. At one extreme is the Danish 'water supply tax' of some 0.87 US$ m^{-3}, including VAT (value added tax), and at the other are the minimum Water Management Area (WMA) WAC rates in South Africa, of only 0.0004–0.0006 US$ m^{-3}. In the UK the differences in charges between the regions reflect the different levels of WRM expenditure in each region rather than any differences in regional water availability and demand. In South Africa the differences in rates between WMAs may reflect both factors.

Based on the various figures in Table I, a 'typical' WAC rate might be regarded as somewhere in the 0.02–0.05 US$ m^{-3} range, as in the UK, some other European countries, and the Paraiba do Sul Basin in Brazil. This is what it is currently costing to manage the water resources of England and Wales. The much higher WAC rates applied in the Australian Capital Territory (ACT) are because these include substantial sums to take account of the scarcity value of water (assumed as 0.023 US$ m^{-3} in 2003) and the environmental costs (downstream costs) of consumptive water use (0.027 US$ in 2003) (Australian Government, 2005; 2006). In 2003 the water resource management costs for the ACT were estimated to be only 0.044 US$ m^{-3}, similar to the England and Wales WRM costs.

Apart from the ACT example and the England and Wales data, no information was found on how the different WAC rates were calculated and what costs and other elements they contained. With the exception of the Australian, Danish and

Table I. Water abstraction charges in different countries (US$ cents m^{-3})[a]

Country	Surface water (SW)	Ground-water (GW)	Abstractor category			
			Water supply	Industry	Agriculture	Other
Danish water supply tax (1998 charge)			70.0 + 25% VAT	Exempt	Exempt	
Dutch GW tax (2000)			17.0	13.0	Exempt	12.0
Baden-Württemberg					Irrigation	Others
Germany (early 2000s)			GW: 5.0	GW: 5.0	GW: 5.0	GW: 5.0
			SW: 5.0	SW: 5.0	SW: 0.5	SW: 5.0
Czech Republic (1999)	Variable	5.0				
Hungary (1999)	0.6 to 4.0	0.6 to 4.0	Different charges for different user categories			
Poland (1999)	2.8	8.4				
Slovakia (1999)	52.0	2.0 to 52.0	2.0	52.0 ?	?	?
England and Wales, 2007/08	(Charges are different for different Environment Agency regions)					
	2.1 to 5.0	2.1 to 5.0	Same basic charges for all user categories, but adjustments are made for different categories' consumptive use			
Australian Capital Territory:						
2003	6.0	6.0				
2004 (proposed)	12.0	12.0				
2005 (proposed)	15.0	15.0				
2006			33.0	?	?	15.0
Paraiba do Sul Basin,						Aquaculture
Brazil (2004/05?)			4.60	4.60	0.11	0.09
Quebec Province,						
Canada	1.0	1.0				
South Africa, 2006/07:	(Charges are different for different Water Management Areas)					Forestry
Median	Same for SW and GW		0.19	0.19	0.12	0.07
Minimum	'		0.06	0.06	0.04	0.04
Maximum	'		0.46	0.46	0.18	0.11

Source: WRDMAP Water Abstraction Charges desk study, 2006/07. Most of the data were obtained via the Internet.

[a]The charges were converted into US cents values using the approximate exchange rates prevailing in the period for which the original WAC charge figures applied. The original charges figures are from the 1998 to 2007 period.

Dutch examples, however, it seems probable that they are based largely on the level of WRM costs in the different countries. As regards England and Wales, under the 'user pays' principle the British government requires the Environment Agency (EA) to recover the full costs of carrying out their regulatory work. In addition to operation and maintenance and other recurrent costs, the costs to be recovered include depreciation and a 3.5% required rate of return on the value of assets. The EA is not allowed to make a profit from its WAC charges. If it makes a surplus in one year, this must be balanced by a deficit (under-recovery of costs) in the following year.

Inclusion of water resource development (WRD) charges in WACs

Though not explicitly stated, the impression gained from the literature review is that in most countries the WAC charges include an element of water resource development (i.e. infrastructure cost recovery) charge as well as the basic water resource management (resource) charge. In only one case, that of South Africa, is there a clear distinction made between the two, with separate published schedules of WRM and WRD charges (South African Department of Water Affairs and Forestry, 2006).

The widespread incorporation of WRD charges in the overall WAC charge is no problem. In fact, this seems to be a convenient and cost-effective way of recovering the costs of water resource-related infrastructure such as dams and inter-basin transfer works.

WATER CHARGING OBJECTIVES

The OECD review of water-related matters in 29 member countries mentioned above, which was completed in 2005, concluded that recovering WRM costs rather than inducing behavioural change amongst water users was usually the main WAC charging objective, but that WACs were also coming to reflect to some extent environmental costs. Adoption of a broader objective than just cost recovery is also the case in the EU (European Union) Water Directive of 2000. This requires member states to follow the principle of 'recovery of the costs of water services, including environmental and resource costs' and stipulates that 'water-pricing policies (should) provide adequate incentives for users to use water resources efficiently' (EU Water Directive, 2000). Nothing more specific is said about water abstraction charges.

Despite these stated intentions, cost recovery is in practice still the dominant WAC objective. Little mention was found of WACs as a demand management tool. Table II shows examples of stated WAC objectives reported in the literature review.

In at least the initial stages of implementing a WAC charging system, WRM cost recovery, rather than anything more ambitious, would seem to be the most sensible and practical objective, for the following reasons:

- *political advantages*. A WAC charge based on just the level required to cover the costs of regulating and managing the water resource and, in some cases, to recover water resource-related infrastructure costs, is easily justifiable to the water users and is generally accepted by them. In most countries attempts to raise charges substantially above this level to, for example, reflect the assumed economic value of water or the downstream environmental costs are likely to meet strong resistance;
- *data requirements*. Provided that there is an effective abstraction licensing and monitoring system (there is little point in introducing WACs unless this is already in place), the data requirements of a cost recovery-based WAC system are not heavy, especially if it is based on licensed abstractions rather than actual abstractions. The key data required are simply the budgeted WRM expenditures by the department(s) concerned and the licensed or actual abstractions for each water user;

Table II. Water abstraction charging objectives

	WAC charging objective
United Kingdom	WRM cost recovery
France and Spain	WRM cost recovery and funding
Canadian provinces	WRM cost recovery
California water rights fees	WRM cost recovery '
Australia:	
• Australia Capital Territory	Cost recovery and 'sending a price signal regarding the true cost of water'
• National Water Commission, 2005	Cost recovery
Paraiba do Sul Basin, Brazil	In practice so far, mainly the generation of WRM and WRD funding, but eventually also to improve water use efficiency
Colombia	Cost recovery
South Africa 1998 National Water Act	Cost recovery and also improved water use allocation and efficiency

- a well-designed WAC system based on a cost recovery objective can still be a useful tool for encouraging abstractors to improve their water use efficiency. First, the fact that they have to pay for the water they use, even at a low price, raises their awareness of the value of water ('water as an economic good'). Second, it is possible to incorporate in the WAC charges substantial incentive elements to improve water use efficiency, even though the overall objective is simply cost recovery rather than water users' behavioural change. The England and Wales WAC system is a good example of this. Two of the three charge adjustment factors in the EA's WAC system do have a substantial incentive element, in that they provide a mechanism for varying the abstraction charge according to seasonal water availability and the consumptive use of different water uses (UK Environment Agency, 2006, 2007/08).

The only detailed example which was found of the composition of a WAC charge including elements other than WRM and WRD costs (elements such as the economic value of water and the environmental costs of water abstraction) was that of the Australian Capital Territory WAC charge. The unusually high WAC charges in Denmark and The Netherlands (see Table I) obviously include very large elements other than WRM costs, but no breakdown of these charges was found.

The great problem with including such items in a WAC charge, in order to meet water use efficiency improvement and other objectives beyond the simple objective of cost recovery, is that of obtaining reliable estimates of the values and costs concerned. The ACT example is unusual, in that Australia, unlike most countries, has a well-developed system of water markets (for example, in the Murray-Darling Basin), from which reasonable estimates of the economic value of water can be derived. Since it also has a generally high level of expertise in water resource economics, realistic estimates of the downstream environmental costs of water use are also likely to be available. Few other countries can match this quality of water-related economic data.

As a result, in most countries the practicability of formulating sound and acceptable WAC charges incorporating more than WRM and WRD costs is limited at present. Moreover, as explained further below, the impacts that WACs have on water use and water use efficiency are also very limited, unless they are set at very high levels, far above those needed for cost recovery. In most countries such high WAC charges would be politically unacceptable.

Given this situation, cost recovery, with appropriate incentive elements built into the WAC charging system, is the most sensible WAC objective under the present circumstances prevailing in most countries. In general, there would seem to be little point in trying to include other, more sophisticated, objectives in WAC charging systems at this stage. This conclusion that cost recovery rather than demand management is the most realistic charging objective is the same as that which was reached for irrigation service charges in the ISCs review mentioned in the Introduction.

THE USE OF WATER ABSTRACTION CHARGE REVENUES

Revenues raised through WAC charging either go into the general pool of local, provincial or central government funds, where they can be used for a wide range of purposes not directly connected to water resources, or they are retained within the water resource sector and spent on water resource management and development, i.e. they are 'earmarked' or 'ring fenced'.

In most countries the WAC revenues are earmarked. In fact, the need to generate funds for water resource management and development is often used as a major justification for the introduction of WAC charges. This is particularly the case in the UK, at the EA region level as well as the national level. Of the 15 countries for which information was available in the OECD 29 countries review, 11 have the revenues wholly or partially earmarked and in only 4 do the revenues instead go into local, provincial or state budgets. Earmarking is also widespread in the countries of Central and Eastern Europe (at the time of the review few of these countries were OECD members) (ECOTEC, 2001). In Brazil the Federal Water Resources Law of 1999 stipulates that not more than 7.5% of the WAC revenues can be transferred for use outside the river basin in which they were raised (Formiga-Johnsson *et al*., 2007).

Earmarking of WAC revenues is highly desirable, not only to promote the acceptance of WACs amongst the water users but also as a means of helping to ensure an adequate level of expenditure on WRM and WRD. The same principle applies for irrigation charges and other water service charges. Experience indicates that in countries with a strong democratic tradition, like Australia, USA and UK, it is probably impossible to introduce WACs without an earmarking policy. Even with earmarking, only limited progress has been made in introducing WACs in the states of Australia, due to political resistance, as noted above. A key water users' demand in the successful setting-up of the WAC system in the Paraiba do Sul Basin in Brazil ((Formiga-Johnsson *et al*., 2007), which was accepted, was that the revenues raised should be reused within the basin.

In keeping with the earmarking principle, and also its strongly regional (decentralised) approach, under the England and Wales Environment Agency WAC system each region has a separate water resources account into which WAC revenues are paid and from which its WRM

activities are funded. Establishment of separate accounts for the management of WAC revenues is a good way of reinforcing the earmarking principle.

EFFECTS OF WACS ON WATER DEMAND AND USE

The conclusion from almost all countries which apply WAC charges is that these have comparatively little impact on water consumption and water use efficiency and make up only a very small percentage of the total costs of water-using enterprises. The only example found where WACs had brought about a substantial reduction in water use and improvement in water use efficiency was that of the Danish water supply tax (there may also be examples from Israel, but these were not found). This is reported to have resulted in a 13% reduction in consumption and a 23% reduction of leakage in water supply systems.

This finding is of limited general relevance, however, because the Danish WAC rate was so high – at about 0.87 US$ m^{-3}, some 17 times higher than the 'typical' rate of no more than 5 cents m^{-3} which is applied in many countries. Where the WAC rate is based on the level of charge required in order to recover or fund WRM and WRD costs, which is the case in most countries (i.e. cost recovery is the charging objective), the resultant rates are too low to have a significant impact on water use. As noted above, this is a similar conclusion to that reached with respect to irrigation service charges in the HR Wallingford and WRDMAP international reviews of irrigation charges carried out in 2002–2004 and 2006/2007 respectively.

This conclusion is supported by evidence from the literature review. For example, an analysis made of spray (sprinkler) irrigation in England and Wales, based on a survey of eight river catchments, found that a doubling of the existing WAC rate, to 0.08 US$ m^{-3} (4 pence), would have little impact and that significant reductions in water use could be achieved only with increases in rates of 1 US$ (50 pence) or more per m^3 (Department of Environment, Food and Rural Affairs (DEFRA), 2000). Such high WAC charges would be completely unacceptable in the UK.

A recent survey of some 1500 farmers in England and Wales found that WAC charges made up only 3% of their total farming costs (data provided by the National Farmers' Union). In Scotland it was found that WACs would make up, at most, only 1.1% of enterprise costs, even for the heaviest water users like fish farms, breweries, farmers and the chemical industry (Scottish Environmental Agency, 2005). A 1999 estimate in Ontario Province in Canada (Canada Policy Research Institute, 2004) concluded that the introduction of WACs would increase the costs of manufacturing by between only 0.01 and 0.2%. Similar conclusions regarding the very small proportion of enterprise costs accounted for by WACs, and the resultant limited impact that any realistic and acceptable level of WAC charge would have on water use, have been reached in other studies.

Despite the above findings, the introduction of WACs does have a useful awareness- raising role amongst water users, by encouraging their understanding that water does have an economic value.

PRACTICAL ASPECTS OF WATER ABSTRACTION CHARGING SYSTEMS

The practical experience gained with operating WAC systems in different countries was considered to be of considerable potential interest to the Chinese water management authorities As noted in the Introduction, however, most of the detailed information on the practical operation of a WAC charging system came from the England and Wales Environment Agency (EA). It was obtained largely from its Anglian Region, which is the most water-short region of the UK, by means of personal communication and correspondence. Only limited information on practical aspects in other countries was found in the literature review.

Administration and staffing of the WAC charging system in the EA Anglian Region

The WAC charging system in this and all other EA regions is closely linked with the abstraction licensing system. In 2007 the Anglian Region had some 5400 licensed abstractions (those with an average abstraction of more than 20 m^3 day^{-1}—water users abstracting less than this do not require a licence). All abstractors are required to record their abstractions and all substantial abstractors have to meter them; in 2007, 76% of the Anglian Region's licensed abstractors had meters. At the EA's national headquarters there is a National Abstractors Licensing Database (NALD) which maintains the details of all the approximately 23 000 abstractors in all the EA's nine regions.

Based on returns submitted by abstractors and EA water resources staff three times per year, a Water Resources Regulatory Officer at Anglian Regional Headquarters produces the necessary computer files of data for the purpose of the WAC billing of each abstractor. These are sent to the EA's national Exchequer, Finance and Accounting Services (EFAS) centre, which serves all the EA's regions. Using the data from the NALD, the EFAS then produces the invoices and sends them out to all the abstractors, receives payments and chases debts. WAC revenues received and attributable to each region are passed through to the region and paid into its water resources account.

Most licence holders are billed once per year, in March. Payment is due within 28 days. However, licence holders

can instead choose to pay their bill in 1, 2 or 4 instalments during the year, by direct debit from their bank. There are no specific penalties for late or non-payment, but non-payers are referred to external lawyers or debt collectors, and cancellation of the abstraction licence can result. Late and non-payment is not a significant problem in the Anglian Region. In 2006/07 there was only one prosecution and two formal cautions in the region. Such legal cases are usually for over-abstraction rather than non-payment of WACs.

Staffing. In EFAS there is a total of four FTEs (full-time equivalent employees) who deal with all the regions except Wales (i.e. eight regions). Thus the average staffing ratio in the EFAS for the WAC charging system is 0.5 FTEs per region. For the Anglian Region this average of 0.5 FTEs dealing solely with WAC charging compares with the total of about 40 FTEs employed in the region for the abstraction licensing and related water resource matters. For the 8 regions in total there are some 150 staff involved in running the abstraction licensing system, as compared with just the 4 FTEs in EFAS for the WAC system.

Based on these figures, the incremental cost of introducing WAC charging where there is already an effective abstraction licensing system in operation can thus be expected to be very low; much the most demanding and time-consuming part of the exercise is establishing and operating the licensing system. Once this has been done, it is relatively easy and inexpensive to introduce WAC charging, using the register of licensed abstractors as the basis.

Linkage of WAC charging with abstraction licensing

WAC charges are normally introduced to complement and reinforce, but not replace, C&C (regulatory) measures such as abstraction licensing. As explained above, they are intimately linked with abstraction licensing, because an effective WAC charging system cannot be operated without a register of abstractors.

Collection of WAC revenues

Normal international practice is for the water resource management agency which operates the abstraction licensing system to also operate the WAC charging system and collect the revenues. Concerns were raised about possible difficulties of achieving high WAC collection efficiencies in China, especially in view of the existing problems there with collecting irrigation service charges. In general, however, it is reasonable to assume that, if the institutional and technical capacity to operate an abstraction licensing system effectively is in place (a demanding task in itself), that capacity would also be adequate to ensure a high WAC collection efficiency. Moreover, in the case of WACs there is the ultimate sanction available for non-payers, namely the withdrawal of the water user's abstraction licence. This sanction is, of course, only effective if the prohibition of any further abstractions by the non-payer can be enforced in practice.

Practical challenges and constraints to WAC charging

A major review for Latin America of the use of economic instruments (EIs) such as WACs identified five main types of challenge and constraint (Kraemer *et al*., 2003a). They are the following:

- institutional and administrative challenges: for example, an inadequate legal framework, due to limited progress in modifying water laws and ineffective legal means of penalising non-payers and late payers, lack of integrated river basin management, inadequate integration and cooperation between different administrative bodies, the advantages and disadvantages of decentralisation, and the inadequate involvement of stakeholders;
- human resource constraints: shortages of the skilled staff needed to operate the system;
- financial challenges (budgetary constraints): for example, inadequate funds may be available to introduce the necessary monitoring of water consumption;
- lack of data, on hydrology, meteorology, water quality, water use and its efficiency, and other important parameters;
- social challenges: e.g. possible adverse impacts of WACs on the incomes of the poor.

The first four of these challenges are, of course, just as applicable to abstraction licensing and other C&C measures as they are to WACs and other economic instruments (EIs).

In the same Latin American review of EIs eight factors for the success of EIs like water abstraction charges were listed, as follows:

- capacity building, to develop the necessary institutional and management capacity;
- spatial organisation (river basin management);
- decentralisation and integration. The need for a decentralised system, with regional or river basin institutions managing the licensing and WAC charging, is mentioned by other authorities as well;
- charging the full costs;
- cross-subsidisation (e.g. to assist low-income groups), if necessary;
- public education programmes, for awareness raising and other WRM-related purposes;
- earmarking of revenues;
- transparency.

Experience with the successful introduction of the Paraiba do Sul River Basin WAC charging system in Brazil is of interest from the practical viewpoint. This system was reportedly introduced 'with relative ease' (Formiga-Johnsson *et al*., 2007). Key factors behind this success were reported to include: the flexible, participatory and transparent approach adopted by the authorities concerned; full (100%) earmarking of the WAC funds raised, for reinvestment within the basin; the system of WAC charges adopted was kept as simple and low-risk as possible; the high level of technical knowledge and capacity in the basin and in the national water agency involved; and the attractive financial inducements which were offered by the federal government for the adoption of the abstraction charging system.

The main problem mentioned with regard to the operation of the Paraiba do Sul River Basin WAC system was that the process of identifying and incorporating all water users (i.e. the inventory and licensing process) is not yet complete and illegal water use occurs. This illustrates the point made earlier, namely that the abstraction licensing is the most difficult part of the development of an effective water abstraction management and charging system. Despite its well-planned WAC approach and system, South Africa has had exactly the same problem.

CONCLUSIONS WITH REFERENCE TO FUTURE WATER ABSTRACTION CHARGING POLICIES

Though originally presented for the benefit of future water abstraction policy in China, the conclusions listed below are in fact relevant to any country which is considering the introduction of a water abstraction charging system or the modification of an existing system:

- *the justification for and role of WACs*. Water abstraction charges increase water users' awareness that water has an economic value and can play a vital role in helping to fund water resource management and development. They can be expected to be highly cost-effective because, once an effective abstraction licensing system is in place, the incremental costs of introducing abstraction charging are low. WAC charging should be viewed as complementary to, rather than a replacement for, command and control (C&C) measures such as abstraction licensing and water allocations. It should be recognised that WACs generally have only a limited effect on water demand and water use efficiency, unless the WACs are set at unusually high, normally unacceptably high, levels far above those needed for cost recovery purposes;
- *choice of WAC charging objective*. Bearing in mind the limited effectiveness of WACs as a demand management tool, international experience indicates that cost recovery is the most common and realistic WAC charging objective, at least at present in most countries. It can be conveniently used as a means of recovering or funding the costs of water resource infrastructure (development) as well as water resource management. WAC levels based on just cost recovery requirements are usually acceptable to water users, whereas raising WACs above cost recovery levels in order to reflect the economic (scarcity) value of water and the environmental costs of its use is likely to provoke strong resistance. Moreover, in most countries the data required to enable such values and costs to be estimated with an acceptable degree of accuracy are not available;
- *preconditions for introducing WAC charges*. Successful introduction of WACs requires at least the following: an effective abstraction licensing system; the necessary legislation to permit WACs and the institutional capacity to apply them; and the political will to apply them;
- *WAC system design options and principles*. Once the basic objective of a WAC system has been decided, there are a number of options to be considered with regard to its design. These include:
  - what costs to include in the WAC charge? Typically, these should include at least the full recurrent (operation and maintenance) and depreciation costs of the water resource management (WRM) system and, if the WAC charges are also to include an element water of resource development (WRD) costs, the same items for WRD;
  - different WAC charges for different water user categories? Few countries have uniform charges for all users. Differential charge rates is the most logical approach, because this enables rates to be varied to take account of *inter alia* differences in the degree of consumptive use (return flows) and in payment capacities (affordability) between different types of user; this is especially important in the case of irrigation, as a water use with a relatively low payment capacity. Most countries charge a considerably lower rate for agriculture than for other water uses;
  - different WAC charges for different seasons? Where there are major differences in water availability, and also demand, between different seasons of the year, it is logical to vary the WAC rates according to season, to reflect the relative degree of water abundance or scarcity, as is the practice in the England and Wales system;
  - different WAC charges for surface water and for groundwater? Many countries have different charges for the two types of water source. Where, however, there is a clear hydrological linkage between SW and GW, it would seem, in principle, more logical to apply the same WAC rate for both;

  - WAC charging on the basis of licensed abstractions or actual abstractions? Some countries apply the former option and others apply the latter—there is no consistent pattern. From the WRM viewpoint the latter is preferable, but it is more expensive and, since WAC charges generally do not influence the volume of abstractions significantly, the extra cost may be difficult to justify. If the WAC charging objective is just to recover the budgeted costs of WRM, there are sound reasons for adopting the simpler and less costly option of basing the charges on licensed volumes, at least initially;
  - the minimum abstraction level for WAC charging? This is basically a matter of licensing policy rather than WAC policy. In England and Wales water users abstracting less than $20\,m^3\,day^{-1}$ do not require an abstraction licence and do not pay WACs. In certain other countries this $20\,m^3\,day^{-1}$ lower limit may be too high a minimum;
  - *use of WAC revenues*. International experience demonstrates clearly that WAC revenues should be earmarked for use in the water resources sector.
- *practical considerations*. In addition to aspects covered above, international experience indicates that the following factors are important for the successful establishment of WAC charging: (i) keep the schedule of charges as simple as possible—avoid unnecessary complexity; (ii) effective awareness raising, consultation and transparency are essential as a means of obtaining the full acceptance and cooperation of the affected water users; and (iii) as part of the overall WRM system, decentralise operations as far as is practicable, with management based on regional or river basin organisations.

With regard to WAC collection, normal international practice is for the WRM agency which operates the abstraction licensing system to also operate the abstraction charging system and collect the revenues. In most countries the normal administrative and legal systems used by public sector agencies for the collection of service charges from users can be used for the collection of WAC charges.

ACKNOWLEDGEMENTS

The author wishes to thank Mott MacDonald and the Chinese Ministry of Water Resources, for whom this desk study was undertaken, the Anglian Region of the England and Wales Environment Agency, Simon Howarth for his comments on the draft, and the numerous individuals and organisations in different countries who were kind enough to provide information and opinions.

REFERENCES

Australian Government. 2005. *Water Reform Assessment Framework*. Canberra.

Australian Government. 2006. *National Water Initiative*. Canberra.

Canada Policy Research Initiative. 2004. Economic Instruments for Water Demand Management in an Integrated Water Resources Management Framework. Synthesis Report: Ottawa.

Chinese Ministry of Water Resources and Mott MacDonald Ltd. 2006/07. Natural Resources Economist's 2006 and 2007 reports. Beijing.

ECOTEC Research & Consulting, in association with CESAM, CKM, University of Gothenburg, UCD and IEEP. 2001. Study on the Economic and Environmental Taxes and Charges in the European Union and its Member States. Final Report: London.

European Union (EU). 2000. *Water Directive*. Brussels.

Formiga-Johnsson RM, Kumler L, Lemos MC. 2007. The politics of bulk water pricing in brazil: lessons from the Paraiba do Sul basin. *Water Policy* **9**(1): 87–104.

HR Wallingford. 2004. *Guidelines for Irrigation Charging*. United Kingdom, Wallingford.

Kraemer RA, Castro ZG, da Motta R, Russell C. 2003a. *Economic Instruments for Water Management: Experiences from Europe and Implications for Latin America and the Caribbean*. Inter-American Development Bank: Washington, USA.

Kraemer RA, Pielen B, Leipprand A. 2003b. Global review of economic instruments for water management in Latin America. Working Paper, February. Ecologic: Berlin.

OECD. 2005. *Water: the Experience in OECD Countries*. Paris.

OECD Development Centre. 1996. *Applying Economic Instruments in Developing Countries: from Theory to Implementation*. Paris.

Republic of South Africa. 1998. *National Water Act of 1998*. Pretoria.

Republic of South Africa Department of Water Affairs and Forestry. 2006. *Water Resource Management Charges for 2006*, Pretoria.

Rogers P, Bhatia R, Huber A. 1998. *Water as a Social and Economic Good: How to Put Principle into Practice*. Global Water Partnership Technical Advisory Committee: Stockholm.

Rogers P, de Silva R, Bhatia R. 2002. Water is an economic good: how to use prices to promote equity, efficiency and sustainability. *Water Policy* **4**.

Scottish Environment Protection Agency (SEPA). 2005. *A Review of Scottish Environment Protection Agency and Environment Agency Charging Schemes for 2005/06*, Stirling.

UK Department of Environment, Food and Rural Affairs (DEFRA). 2000. *Economic Instruments in Relation to Water Abstraction*. United Kingdom: Bristol.

UK Environment Agency. 2006. Review of the Water Abstraction Charges Scheme. Second Consultation Response Document: Pretoria.

UK Environment Agency. 2007/08. *Schedules of Abstraction Charges, 2006/07 and 2007/08*. Bristol.