China – UK, WRDMAP
Integrated Water Resources Management Document Series

Thematic Paper 3.1: Water Saving in Irrigated Agriculture

3. Demand Manage-ment

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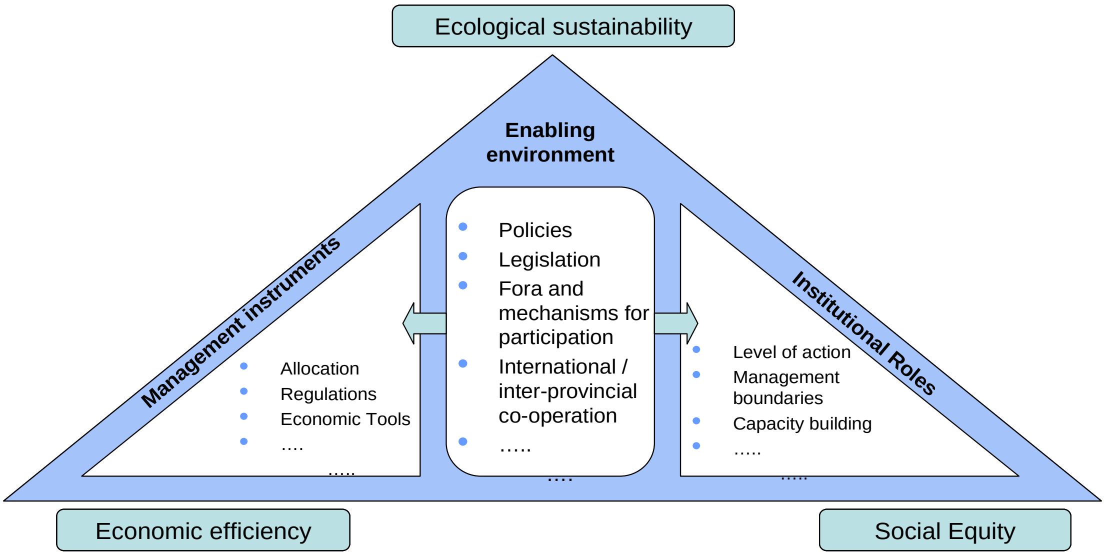
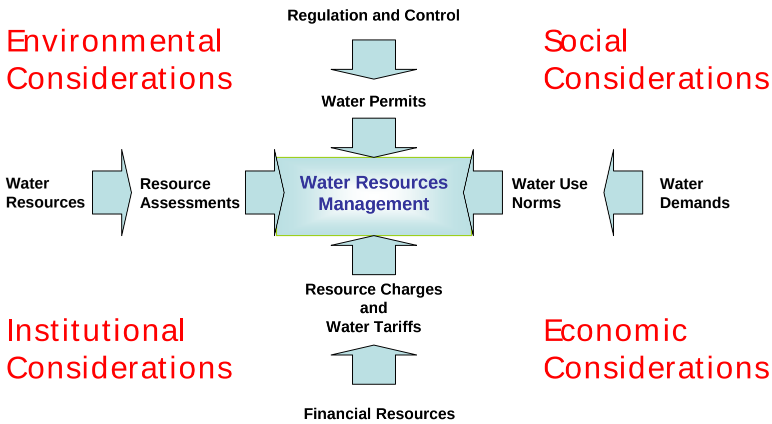
Integrated Water Resources Management (IWRM)

(Basics after Global Water Partnership)



Driving Elements of Integrated Water Resources Management



(Second figure after WRDMAP)

Summary: This document outlines recommended approaches for saving water in irrigated agriculture, as part of establishment of a Water Saving Society. It is aimed at Water Affairs Bureaus at Municipality and County levels, and makes reference to other more detailed documents which describe practical approaches for introducing these methods of water saving.

This document has the following sections:

- Introduction
- Administrative measures: norms, rights and permits
- Economic tools: water resource fees and service charges
- Technical measures related to water use efficiency
- Social change tools: participation and awareness
- Incentive to promote and adopt water saving
- Conclusions

This document is one of a series covering topics on sustainable water resources planning, allocation and management. Details are given in the bibliography. It should be read in conjunction with Advisory Note 3.1/1 'Agricultural Water Saving Techniques' and Advisory Note 3.1/2 'Practical Techniques for On-Farm Water Saving.'

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 concept of a water saving society has been developed in China to help resolve the problems caused by a severe shortage of water: the productivity of water is relatively low, and environmental conditions have deteriorated in recent decades. Successful construction of a water saving society relies, amongst other factors, on reducing demand for water, creating an awareness of the need to save water, and developing the skills and understanding needed to achieve these savings. The objectives of the society should be clearly defined and agreed.

Water saved from one use can then be made available for other, more productive uses or for enhancing environmental conditions. In the context of agricultural water use, water saved may be used for more intensive agriculture in the same location, agriculture in other areas, transferred to other sectors (typically urban or industrial), or released to the environment. In addition to methods for saving water in one sector (in this case, agriculture) it is necessary to identify the uses of water saved, and to introduce monitoring systems to assess the amount of water saved. Flow measurement is not easy, and quantifying actual water savings is not a straightforward task.

This document summarises the options for water savings in agriculture with a focus on North China. Monitoring systems are discussed in a separate guideline document on auditing water savings societies.

This document supports the NDRC announcement No.17 of 2005 on *'methods for achieving agricultural water saving',* which outlines the range of technical measures available, and puts them into the broader context of Integrated Water Resources Management (IWRM).

In addition to methods for saving water, however, it is necessary to consider the incentives for farmers and water managers to save water. Water savings techniques need to be designed to maximise the incentive, and further activities may be necessary to ensure that water savings measures are actually implemented.

This document is structured around the various tools relating to water savings described in the 'IWRM toolbox', as prepared by the Global Water Partnership, but it does not present full technical details of water savings technology, for which information is available in many publicly available texts and reports. The tools for water savings include:

- Administrative measures
  - Norms for water use (by crop type and situation)
  - Water Quotas and Rights
  - Water Abstraction Permits
- Economic measures - irrigation service charges and water resource fees
- Technical measures related to water use efficiency
  - Agricultural structure (crop choice)
  - Agricultural practices and irrigation techniques
  - Modern irrigation systems (drip and sprinkler irrigation, etc)
  - Irrigation system management
    - O&M of canals, pumps and structures
    - Canal lining and repair
    - Flow measurement infrastructure
- Social change tools – participation and awareness
  - Participation in management of canals and wells
  - Participation in water abstraction and flow monitoring
  - Awareness of water resources, savings, permits
  - Knowledge and understanding of fees – reasons for changes, uses of fees etc
  - Trust in the water management system and use of the fees collected
  - Ensuring that all farmers across the irrigation district comply equally

The document introduces each of the above water saving measures, but refers to other Advisory Notes produced in this series, or other documents, for more detailed advice on how each could be implemented. This document is therefore aimed at water management officials in WABs wishing to understand the potential impacts of alternative water saving options.

There is a considerable amount of information available on water saving in agriculture on the internet: it is not the intention, nor is it possible, to cover all of these methods in this document or to repeat information which is readily available. This document aims to provide a balanced overview of water savings in irrigated agriculture in China.

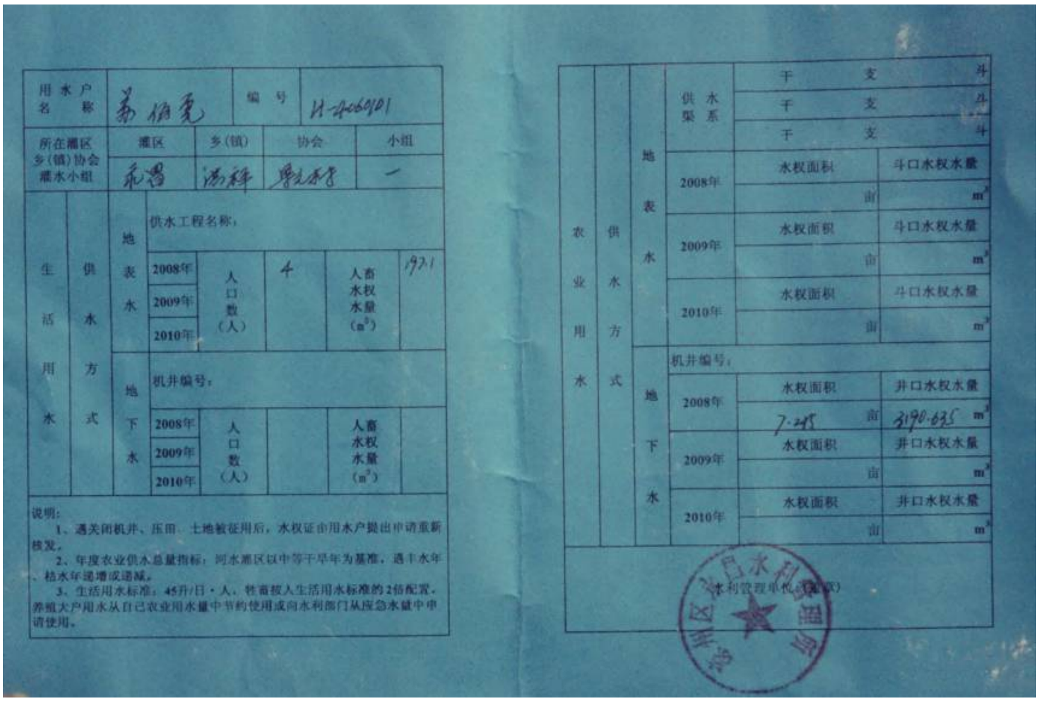
2 Administrative Measures: Norms, Rights and Permits

Total amount and quota management is highlighted as a priority in the NDRC announcement No 15. This depends first on defining farmers' rights to water, on the basis of realistic water use norms which are based on the water requirements of the predominant crops, and then to ensure that farmers do not exceed these quotas. Permits are issued for each abstraction point (surface or groundwater), which entitle farmers to access no more than this volume of water. In future they may be entitled to sell this right to water.

The basis for norms, rights and permits and their method of implementation is defined in other documents (see bibliography). The successful use of these tools depends on transparent systems for management, ensuring compliance, and monitoring the impact on water resources.. This section aims to put these administrative measures into the broader context of water savings society implementation in agricultural areas.

2.1 Water rights

It is widely recognised that clearly defined water rights are a pre-requisite for sound water management. For this reason, water 'rights' are now being allocated to each household, and in some places these are recorded on household water rights certificates (which also has space for farmers to record how much water they have actually received). These 'rights' are not legally defined but they do assure the holder of their entitlement to a volume of water which should be sufficient to meet the irrigation norms for the recommended cropping pattern and thus maintain their livelihood.



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所在灌区乡(镇)协会灌水小组 灌区 乡(镇) 协会 小组
生活用水 供水方式 地表水 供水工程名称：
2008年 2009年 2010年 人口数(人) 人畜水权水量(m³)
地下水 机井编号：
2008年 2009年 2010年 人口数(人) 人畜水权水量(m³)

说明：
1、遇关闭机井、压田、土地被征用后，水权证由用水户提出申请重新核发。
2、年度农业供水总量指标：河水灌区以中等干旱年为基准，遇丰水年、枯水年递增或递减。
3、生活用水标准：45升/日·人，牲畜按人生活用水标准的2倍配置。养殖大户用水从自己农业用水量中节约使用或向水利部门从应急水量中申请使用。

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Household water right certificate

In the case of groundwater, the right usually applies to the amount supplied from the tubewell; in the case of surface water the right usually relates to the amount delivered to the head of the tertiary canal. The WUA and WUG need to manage water efficiently so that farmers receive their fair share of the amount at the well or canal head (see Section 4)

These rights are calculated from crop norms and areas, but the total of the rights should also be no more, in total, than the sustainable availability of the resource. In many places in North China, including the Shiyang River Basin, resources are overcommitted and the ‘rights’ will need to be gradually reduced until supply and demand are in balance,

In most situations, the ‘right’ will be for less water than they have received in the past. It is, however, intended that the formal issuance of a rights certificate for this amount of water will help ensure a more reliable and predictable delivery of the entitlement. This should improve the predictability of agriculture and thus help farmers cope with a reduced amount of water. Other measures may also be introduced to help compensate farmers for the reduction.

These rights are, however, not ‘water rights’ as normally understood internationally as they do not have an enforceable legal status and they are subject to .adjustment every year (although the anticipated norms may be decided some years in advance). They provide some assurance of the amount of water which an individual will receive, but not the long term guarantee which they need for planning or investment in agriculture.

Box 1: Water rights and allocation

A **water right** is the right to take and use water subject to the terms and conditions of the grant. It is a formal or informal entitlement, which confers on the holder the right to withdraw water. **Water-use rights** are conferred through an administrative process of water allocation, such as licensing. **Water allocation** is the process in which an available water resource is distributed (or redistributed) to legitimate claimants. (*Bird, Arriens and Custodio, Asian Development Bank 2009*)

2.2 Norms and quotas

The water rights are based on water norms which represent the recommended volume and schedule of water deliveries for each crop. The norms are expressed as a volume per unit area (m3/mu), and are converted into a quota as a volume per household on water rights certificates. In places, these norms are being reduced as a way of stimulating water savings. The reductions in norms should be based on realistic assessment of what savings can be achieved through use of better techniques, rather than be an arbitrary reduction – the socio-economic impact of norms should be monitored.

These household quotas can be aggregated into a volume per well or canal system and compared with the volume defined on the abstraction permits. The permit volume is based on the long term sustainable availability of water resources, and thus it is important that the aggregate of water rights does not exceed the abstraction permit volumes.

It is important to remember that norms per unit area (and hence quotas per household) are usually defined as the amount of water that should be pumped from a well or delivered to the head of a tertiary canal, rather than the amount delivered to an individual field. The various types and definitions and method of calculating norms, and the rationale or implications of reducing norms is discussed in Advisory Note 1.8/2 ‘Agricultural Water Use Norms’.

As the quotas are presented on a volumetric basis in China, they need to be monitored volumetrically. Flow measurement can be difficult or inaccurate, although flow meters are gradually being installed on tubewells in some areas. Flow measurement on surface irrigation systems is much more difficult.

In places were flow measurement is not accurate or is impracticable, alternatives methods of presenting the quotas are possible and are sometimes simpler to apply. For example, water quotas for agriculture can also be expressed on an area basis, as it is easy to observe crop areas and this is simpler than measuring volumes of water. These are compared below for information

Volumetric quotas are standard in China, but internationally both methods are used. In Spain, for example, various different approaches to water quota calculation and management are used, as described by Lopez-Gunn [2003] and Luis Martinez Cortina and Lopez-Gunn [2005]. Some of the advantages and disadvantages of volumetric and area-based methods are outlined below.

Table 1: Comparison of volumetric and area-based methods for defining quotas

Advantages	**Disadvantages**
Volumetric quotas (based on total land area held by household, and expressed as a volume)	
• Easily related to household water rights and to the volumetric water fee.	• Need to measure water volumes to monitor actual water used (requires numerous measurements of flow rates and durations with the possibility of inaccuracies and problems of data management) • Might result in less efficient water use if areas authorised for actual cropping are being reduced (fallow land causes unproductive evaporative losses)
Area quotas (based on the area of each type of crop that is allowed, expressed as an area).	
• In effect a quota for water consumed rather than for water pumped/delivered. • Can monitor crop type and area as a proxy for actual use (easier to measure than volume of water). • Transparent – those exceeding the quota can easily be identified and charged or penalised accordingly.	• Gives no encouragement to farmers to save water or to practice deficit irrigation. • Difficult to implement in areas where cropping is very diverse (the total water consumption would need to be calculated by converting the area data for each crop into an equivalent volume of water using crop norms.)

Those whose land is close to the well or head of the canal are at an advantage because less of their water quota is lost during conveyance. It is the responsibility of the WUA to ensure that quotas are delivered equitably to all farmers, possibly by adjusting quotas to each field. It might also be worth introducing reduced quotas for production groups with lined canals (compared to production groups with unlined canals). WUAs may choose to introduce a proxy method of monitoring quotas, particularly in surface irrigation, where area-based equivalents may be more practical (However, they still need to calculate the volume of water since regulations in China require that water is paid for on a volumetric basis. This differs from many other countries where water charges are based on area irrigated as this is easier to assess than volume of water delivered).

2.3 Water abstraction permits and annual allocations

Current and recommended procedures for issuing and managing permits, which are intended to control abstraction to the sustainable yield of an aquifer are described in other documents (see bibliography). The permits are issued with a typical validity of 5 years, and. like the 'rights', in the past have based on the norms rather than on the resource availability. Permits issued in the future should be related to the resource a availability, and allocated volumes need to be gradually reduced to match the sustainable yield of the resource over a period of years depending on the degree of stress in the river basin. It should be anticipated that the by the next renewal of the permit the allocated volume will have been reduced to the sustainable level through this process of enforced "water savings" (due to imposed reductions in irrigated areas and norms). Subsequently in accordance with State Council Decree 460, permit holders can save additional water and sell the right to this saved water to other users. It can thus be seen that China is in a transition phase between implicit and explicit allocation systems [see box].

The allocated volume per well is expected to be equal to the total of the newly issued water rights as presented on the household water rights certificates for that year for each household drawing water from that well. Care is needed when comparing the rights and permits to ensure that the volumes are aggregated correctly since farmers may use water from more than one well. Administrative procedures are potentially complex and time-consuming. These will need to designed carefully to reduce excess bureaucracy.

中华人民共和国

取水许可证

取水（永）字[2006]第1554号

根据《中华人民共和国水法》、《取水许可制度实施办法》等法规，经审查，批准 头河面粉厂 按规定在 头河村委会院内，取 地下 水，年取水量 20.24 万立方米，特发此证。

取水有效期限：自 2006 年 3 月 20 日

至 2011 年 3 月 19 日

发证机关（印章）

中华人民共和国水利部

发证日期：2006 年 3 月 20 日

Water abstraction permit

Box 2: Water Allocation Systems

Beyond having access to water for meeting domestic needs, what rights do individuals or organizations have to water for urban consumption, irrigation, industrial production, commerce, generating electricity, or navigation? How are such uses authorized? In general, two approaches are used to define these rights:

> **Implicit Approach:** top-down, government driven planning processes in which the quantities of water for specific development projects are determined and then become accepted practice….
>
> **Explicit Approach:** allocation through a system of time-bound licenses or permits to specific users, whose supply is then secured for a defined quantity of water for a stated period.

In an **implicit allocation** system, users have only limited security in the form of rights and do not have opportunities for redress when water is reallocated for another use. An **explicit allocation** system provides time-bound licenses or permits to specific users, whose supply is then secured for a defined quantity of water for a stated period.

Water shortage provides a critical test for any allocation system and its administration. Variability in climate and hydrology are natural phenomena. Annual fluctuations in dry season flows may be significant and need to be factored into decisions on the security of supply and the quantity of water available for allocation.

To accommodate extreme drought situations, licensing conditions generally make it clear that although an amount of water is specified for extraction from the source, this is not a guaranteed amount. Developing a comprehensive drought strategy that is consistent with a water rights system is a major challenge.

It is important to note that regulatory frameworks usually do not provide for compensation to water users for losses during extreme climatic conditions. This would generally fall under government programs for drought relief, including crop insurance.

2.4 Enforcing allocations

In severely stressed river basins in North China, there is little incentive for individual farmers to save water. It is necessary to ensure that each farming household complies with their individual 'right' and that WUAs, or well or canal operators/production groups comply with their allocations.

It is very hard to achieve compliance in groundwater systems as it is difficult to monitor let alone control the amount abstracted from large numbers of small wells. Flows from pumps can be measured fairly accurately by meters installed in the pipework, but these are costly. Alternative methods include estimating according to duration of pumping or to electricity consumption. These methods rely on calculation of conversion factors between time or electricity and water volume, which will vary according to depth to table and pump condition and will need to be checked periodically.

Farmers or production groups control the amount of water which is pumped. They are reluctant to limit their water use as their livelihoods are dependent on water. They also need to be sure that all farmers are limited to the same share of water. This is why cooperative management is important (see Section 5). Supplies to surface water systems are managed by water management divisions and it is easier to control water delivery, whether from reservoir, river diversion or pump station. However, there other difficulties – losses in the system and destination of return flows are difficult to calculate or measure, so the relation between allocation at the headworks and the allocation to individuals is not straightforward. Furthermore, flow measurement is difficult and expensive, yet management depends on accurate measurement and systematic analysis of the data collected.

In both cases, there is a need to improve the systems for measuring flows and to make farmers aware of the need to comply with the permits, and possibly install equipment which will physically limit abstractions and thereby enforce quotas. In the case of groundwater, this can be achieved either through:

(A) limiting electricity supplies to wells, by cooperation with the electricity supplier so that electricity supplies would be curtailed once farmers has exceed their electricity quota; or

(B) installing IC cards to switch off pump controls once the permitted volume has been pumped or number of units of electricity has been used.

For Alternative A, all farmers using that well would be affected equally once the well had used its allocation of electricity. The production group would need to manage the well to ensure that individuals do not exceed their individual quota which would then affect other members of the group adversely. This method relies on an accurate calculation of the relationship between electricity and water use (which may need to be revised annually as the water table changes). This same would be true in Alternative B, if there was just one IC card per well. Individual IC cards would avoid this problem, but would still require cooperation within the production group in management of the well.

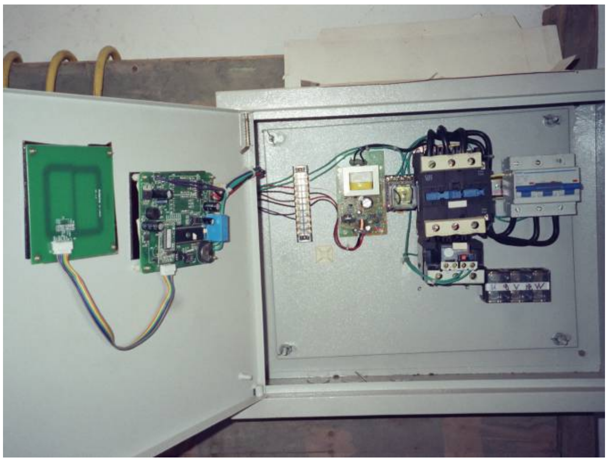
For Alternative A, electricity stations are expected to play a significant role in controlling water use. However, this gives them the unpopular task of restricting water without any natural incentive to do so; indeed they would have a perverse incentive since it would reduce their revenue from electricity sales, even though they have an interest in selling electricity. It would be necessary to design institutional incentives to encourage electricity stations to participate in this.

For this reason, the IC card approach is being widely (though not universally promoted in North China – it is seen as both more effective at controlling supplies and easier to implement. However, it is relatively expensive, and requires careful data management to ensure that cards are used correctly to limit flows to no more than the allocation For more details about the different options for IC card management, refer to Advisory Note 6.1/1 'Role of WUA in Water Saving in Groundwater'.

If neither of these systems for physically limiting abstractions can be put in place, effective enforcement will depend on voluntary controls. These in turn rely on building a good understanding of the reasons for the restrictions, convincing farmers that they are being applied consistently for everyone, and on having strong administrative procedures enforced by the WMS. Whatever system is applied for limiting the amount of water pumped, the WUA at village and irrigation district level will need to help farmers cope with the limited supply.

In all cases cooperative management within the well command area is needed. This can be done by traditional informal means by production groups, but it is likely to be better if a formal WUA is set up (see Section 5).

Monitoring household compliance with quotas relies on a combination of monitoring abstractions from wells or deliveries to tertiary canals, and monitoring the distribution within the well or tertiary canal command area. The production group should record the time and duration of irrigation water use for each farmer (in a notebook held by the well operator). If IC cards and meters are installed, the accuracy of flow measurements will be good, but it will still be necessary to record times for individual farmers. If flows are estimated on the basis of electricity consumption, the calculation will need to be checked periodically (to allow for factors such as changing pumping head, or pump condition). At a larger scale total water consumption can be assessed accurately using remote sensing techniques.



IC Card control box

In-pipe water meter

Return flows are often available for reuse either locally or further downstream. In the case of groundwater, they are difficult to quantify as there is usually little excess surface flow and the losses mainly seep back to the aquifer. They can be quantified by indirect means (by deducting consumptive use from total water applications). Return flows from surface irrigation may well be greater but are also difficult to quantify as they are diffuse and variable in time, and occur at many locations in the tail of the system. Whether they are quantified or not, a target for irrigation managers and WUAs should be to reduce return flows.

More detail relating to the role of WUAs in management of quotas, permits and IC cards can be found in Advisory Note 6.1/1 ‘Role of WUA in Water Saving in Groundwater’.

3 Economic Tools: Water Resource Fees and Service Charges

Increases in fees are often seen to be critical for reducing demand; however, international experience suggests that this generally has less impact on water use than is expected as the value of water is much greater than the price. It should be stressed that the primary purpose of the fees in most places is to recover the costs of water resources management rather than to limit demand. However, well-financed water administration does enable better management and hence water savings. Fees also give a clear indication to farmers that water has a value and should be used efficiently, and thus there is some scope for water savings if the existing management does not give priority to optimising water uses.

However, once any losses which can easily be saved have been eliminated, the effect of increasing prices on water use is often low. Fees will then only influence demand if the fees are raised to a level similar to the economic value of water. This is perhaps ten times greater than the current fee and it is socially and politically unacceptable to raise them to this level (see Cornish, G., Bosworth, B. and Perry, C. [2004]). In the case of groundwater, the electricity charge is much greater than the water fee so even large increases in water fees would result in a small percentage increase in the overall cost of water. Water charges for groundwater thus have even less impact on demand than for surface water.

In the case of surface water, however, farmers are often not able to reduce their water consumption even if prices are increased - because of the way the main canal systems are operated.

For these reasons, it is recommended that the primary motive for collecting fees should be for cost recovery rather than water demand management.

Water ticket

Water resource fees should therefore be structured in a way that enables the costs of administering water management processes and any infrastructure requirements to be recovered (including costs of flow measurement system improvements. If cost recovery is achieved, then there is likely to be a positive effect on standards of water management. It is important that this is evident as farmers will only be willing to pay if they can see their money is being spent on effective water management improvements. If it is not, it will become politically difficult to retain WRFs at the required levels.

WUAs should be authorised to retain part of the fees collected for their own use to cover their costs in managing the resource (particularly to achieve improved water use efficiency), otherwise they will not have the financial resources to be active or effective. Two approaches to WUA fees from Gansu Province are described in Box 3.

Box 3: WUA fee collection in Gansu Province

Until 2007, WUAs in Wuwei were not authorised to collect any fees for their own use; thus they had no financial resources and were not willing to be active, causing dissatisfaction. This has been resolved by two different approaches:

- In **Liangzhou District**, a fee of Y1/mu has been added to the water charges – this is collected by the WUA at the same time as the water resources, basic and management fees, paid to the WMD and returned to the WUA. This is intended to be used by the WUA for staff allowances and other administrative costs.
- In **Minqin County**, the County Government pays the WUA director and vice directors an allowance of Y1,000 and Y800 per year respectively and allowance for administrative costs. This is paid from the water resources fee which is paid by the farmers. Note that this means that the WUA staff are elected by the village, but paid by the Government – this may have some impact on the way they work.

In both cases, the start-up costs for the WUA (registration fees, signboards, etc) were paid by the WMD.

Economic tools are important for water saving, but they generally have an indirect impact – by creating awareness of the value of water and enabling recovery of the costs of better management of water. These tools need to combined with direct methods, as discussed in the following sections.

Further details about water resource management fees and irrigation service charge fees (including methods for calculating fees, objectives of fees, and the impact on water use) are given in Thematic Paper 5.3 'Water Resource Fees' and Advisory Note 5.2 'Formulation of Irrigation Service Charges for Surface Water Irrigation Schemes'.

4 Technical Measures Related to Water Use Efficiency

A wide range of technical measures are listed in the NDRC announcement No.17 of 2005 on "methods for achieving agricultural water saving". This summarises current technology, as well as some techniques still under development and some future research needs

Four stages of technical development are currently recommended in China for improving water use efficiency (WUE) and thus saving water:

- **Agricultural structure, including biotechnological measures**, such as creation of new crop cultivars with better WUE properties or better yield under same water use condition;
- **Field irrigation and agricultural techniques;** such as land levelling, , decreasing plot sizes, using mulches, better irrigation scheduling;

- **Improvements to irrigation systems, through modern irrigation methods,** such as drip irrigation and sprinkler irrigation, and better management operation and maintenance; and
- **Regional scale water management** - for instance reducing water loss in long-distance water diversion, regulating crop pattern through regional water balance calculations.

The first three of these approaches are considered briefly below and are addressed in more detail in Advisory Note 3.1/1 'Agricultural Water Saving Techniques (WMS/WAB level)'. Regional water management is covered to some extent in the context of integrated water resources management at basin level Advisory Note 2.1 'Developing an IWRM Plan'.

4.1 Agricultural structure

The type of crop grown has a major impact on the amount of water used, and hence the value of output per unit of water used. However, the options are limited by a range of factors including agronomic suitability, labour requirements, farmer preferences and knowledge, prices and markets, etc. Farmers will need technical assistance before they are able to grow new crops, and this will need to be backed up with support such as input supplies, credit, marketing advice, agro-processing facilities and so on. Some of this can be provided by local crop associations, but they will need support from agricultural companies (as in the case of seed maize production in Liangzhou district, which is grown under contract to commercial seed companies), and from the agricultural technical extension service. WUAs can have an important role in advising on new crops, or combinations of crops, and should help ensure that farmers have access to reliable information.

Box 4 describes, as an example, crop changes that have been discussed in Yongchang Irrigation District, Gansu Province, in order to reduce water consumption and increase productivity.

Box 4: Options for changes in crop structure to reduce water consumption in Yongchang Irrigation District, Gansu Province

- Reducing the total cultivated area, and growing vegetables in greenhouses under drip irrigation in small areas. These often use a high volume of water per unit area (because of the type or intensity of cropping), but enable a much greater return per unit of water than field crops.
- Inter-cropped maize and wheat on reduced areas. Although this requires up to 800 m3/mu, it is a more productive use of water than single cropping. A greater total yield could be achieved by intercropping on part of the land rather than by single cropping on the whole area.

Other examples of ways to save water include conversion of marginal areas for cultivation of grass for fodder for livestock and cultivation of cotton. Cotton is a water-saving crop as it only requires three irrigations, but it is labour- intensive so may not be viable if farmers also depend on off-farm income. It is often the case that saving water requires more labour, and labour may now be even more scarce, at a household level, than water. Some effective traditional methods have been discontinued for this reason (as described in more detail in Advisory Note 3.1/1 'Agricultural Water Saving Techniques' and Advisory Note 3.1/2 'Practical Techniques for On-Farm Water Saving').

New crops or varieties developed through application of biotechnology offer further prospects for water-saving in the long-term. There are already some wheat cultivars, such as 9204 in Hebei and Youmai No. 2 in Shandong Province, which have been developed through application of biotechnology but they are still undergoing trials and have not been widely applied.

It is important to note that introducing many more profitable crops that give more income per unit of amount of water consumed (such as vegetables and fruit trees) may increase demand for water unless the cultivated area is also reduced since the water use per unit area is often greater than for cereal crops and farmers will seek to maximise their income rather than just meet subsistence needs. Such crop changes should be supported by administrative regulation, as outlined earlier, in order to avoid increasing water use.

In theory, changes in agricultural structure should be the easiest way to achieve water-saving on a particular area. However, the changes do come with some inherent difficulties which need to be considered before they are implemented. Firstly, diverse cropping makes irrigation more complex as the crop water requirements are different for the various crops. This should be easier to manage in groundwater areas, where farmers are less constrained by an inflexible irrigation schedule than they are on areas irrigated by large-scale surface schemes, but some consolidation of crops is still necessary. In Minqin, Gansu, where the cropping includes cotton, melons, spices, oilseeds, wheat and maize, some WUAs are reportedly planning to encourage zoning of crops to simplify operation.

High value crops – leeks and chilis

Secondly, the present agricultural structure is often the most suitable from the point of view of farmer income, skills and risks taking account of their livelihoods as a whole (including off-farm employment and migrant labour). In many areas, particularly those irrigated by surface water, farmers seek to minimise their risk and labour input so that they can cultivate a crop reliably whilst still being able to work in urban areas. In this situation, simplicity and reliability of operation is much more important to farmers than efficiency of water use.

Thirdly, more profitable crops often require more labour and more capital, and possibly unattractive working conditions (eg. the confined, hot and humid environment inside greenhouses, which are popularly believed to encourage rheumatism and other diseases as well as increasing risk of exposure to pesticides). Some grants or subsidies are available to help introduce these techniques (eg for construction of greenhouses), and seed companies are sometimes able to assist (eg by provision of mushroom culture). Knowledge of and access to these sources of assistance is not widespread, nor is there sufficient appreciation of the risks involved in cash crop production.

In general, water-saving by agricultural structure changes has proved difficult. However, there have been some successful cases where government policy has been strong – an example is the reduction of rice planting in dry areas as in Hebei or Zhangye in Gansu.

These factors mean that forced reductions in water supplied will in general reduce crop yields, areas and income, making farmers' livelihoods less secure, and that voluntary reductions are unlikely to be achieved. In addition to technical assistance in these new techniques for using less water, it will be necessary to introduce adequate and transparent mechanisms for compensation and water transfer in order to reach a sustainable water resources situation or provide water to other uses.

Box 5: Mitigation of health risks for greenhouse workers

Many international studies have highlighted the risks to workers in greenhouses, particularly related to pesticide application although physical conditions have also been considered. For example, Petrelli et al (2003) found an increased risk of spontaneous abortion in spuses of greenhouse workers, and Mons (2004) found a relationship between chronic bronchitis greenhouse air contaminants including pollens, moulds, and Tetranychus urticae allergens.

Such problems are being addressed in Ecuador and Colombia through a programme known as Flor Verde (green flower), to improve conditions for workers, through environmental training, planning and monitoring,

4.2 Agricultural and field irrigation techniques

Simple field irrigation techniques can be very effective in increasing water application efficiency, and should be considered as a first step towards agricultural water savings. These include measures such as:

- decreasing the size of each irrigation plot (Experiments in the north China Plain (NCP) suggest that 30 m2 (0.05 mu) is the most suitable plot size, but the impact on the layout and density of channels need to be considered.),

- levelling the field surface so that the irrigation depth is constant across the field,
- loosening soil by ploughing in the dry season,
- covering soil surface with plastic film or straw to decrease soil evaporation (mulching),
- improved irrigation scheduling,
- deficit irrigation and partial irrigation,
- brackish water irrigation,

In rainfed areas, improved rainwater harvesting can be beneficial for agriculture, but this is outside the scope of this guideline.

Many techniques are listed in NDRC Announcement No 17, and further details of these are available from agricultural research stations and literature.

There is considerable scope for adjusting field irrigation techniques, and many of these, such as land levelling, reduction in plot size and application of plastic mulch is strongly promoted by the Government, particularly in the North China Plain, but also in many other parts of North China. Both capacity-building and incentives are needed for them to become widely adopted.

Deficit irrigation is a technique to ensure sufficient water at critical plant growth stages and less than optimum for the remainder. Though the application of systematic deficit irrigation is still limited to small areas, several studies in the North China Plain for instance showed that farmers are irrigating much less than twenty years before. (Most farmers there accept irrigating their wheat three times after re-greening of winter wheat in the spring rather than four to six times as in the past.) This has generally been driven by the cost electricity (which increases as the groundwater level drops), and cost of labour (as most young people have to go to cities for work) rather than by water shortage. Gradual reduction in norms, however, will now encourage more farmers to adopt deficit irrigation, but technical advice will be needed to ensure that they do this in the most effective manner and maximise the productivity of water (as well as labour).

There are extensive government training programmes for introducing new techniques, and crop associations are important sources of advice (for example the Qilian vegetable association in Wuwei, Gansu). Commercial organisations can also assist – for example, maize seed contractors. The tendency for access to training to be dominated by men, however, has meant that the new techniques are not well-known by the women who play an increasing role in managing irrigation and agriculture. It is clearly important that any water savings or other new techniques must involve women, take their other daily constraints into account, and fit in with livelihood strategies.

Many of these techniques have significant impacts on the labour requirements for agriculture,. Farm mechanisation may be needed to offset the labour requirements – for example:

- cotton picking machinery, which is becoming common in Xinjiang province, would reduce the labour constraint which the limits the area under cotton cultivation (cotton is a very water-efficient crop).
- Tractor-drawn tools for making farm ditches, furrows, or land levelling would assist in reducing plot sizes, improving furrow

irrigation and reducing evaporation losses from uneven fields

Such machinery is expensive for individual small farmers, and thus cooperative purchase and management via WUAs may be needed. State farms may be able to introduce these techniques more easily

There are other constraints on some techniques - such as straw mulches, which have been discontinued in many parts of China. The sale of straw for paper-making and the use of straw for fodder are now considered to be more productive uses in some places than mulch. In other places it is simply burnt, because straw mulch interferes with cultivation – although simple machinery to avoid this problem has now been developed.

4.3 Irrigation systems

Drip and sprinkler irrigation

Drip and sprinkler irrigation are common modern techniques for water-saving. Both of them can decrease water losses and ensure precise delivery from well or canal to the crop. However, owing to their high initial and running costs, and high labour requirements, both irrigation methods are very sparsely used in China. Even the operational costs of pilot schemes installed with Government support are sometimes too great for farmers to afford.

Drip irrigation is increasingly used for multiple cropping of high value crops in greenhouses where the growing season can be extended and the value of produce justifies the high costs.

Drip or sprinkler techniques are rarely justified in field crops in north China, but may be considered for extensive cultivation of certain vegetables. Sprinklers are generally considered less successful in Gansu than drip irrigation because of the windy conditions. Investigations into these and alternative techniques are in progress in many parts of China, and these will need to be evaluated in the context of local social, agricultural and economic conditions as well as their technical features. Subsidies have been provided to farmers or demonstrations set up on their land in some areas, but these have not yet resulted in a significant expansion of the technology.

A range of techniques are listed in NDRC document 15, and existing documentation by MWR covers the use of drip and sprinkler irrigation in considerable theoretical detail, and this is not repeated here.

Canal systems

Improving irrigation scheduling is one of the best ways of saving water. This is because operation of large surface irrigation systems is dominated by reservoir and canal operating requirements, and it is often not very responsive to the needs of crops. More precise and flexible scheduling would make it easier for farmers to change their cropping pattern to new crops which need water at different times. At present farmers may even find it difficult to change to crops with a lower water requirement as they may require water at different times – for example, changing from barley to maize, which makes more efficient use of rainfall, is difficult in because it requires some irrigation later in the season and less earlier in the year.

Canal operating systems are often designed to keep management simple, with limited control or measurement, rather than to optimise efficiency of water use. This is done by operating canals at full discharge in a strict order, which just suits a simple cropping pattern. However, it is often possible to introduce some flexibility – albeit at the cost of more intensive management of canals - by operating several canals simultaneously for longer, but at lower discharge rates (see Box 6 for an example). Careful planning, implementing and monitoring irrigation order and timing is needed and this requires keeping scrupulously accurate records of actual irrigation times. This can be a demanding task if irrigation is frequent and there are a number of different plots to irrigate independently. Failure to keep accurate records will undermine the irrigation system, and lead to conflict, wastage of water and inequity.

In other areas, conjunctive management of surface and groundwater can enable more responsive irrigation, with infrequent canal supplies being augmented with smaller, carefully timed deliveries of groundwater from local tubewells.

Maintenance

Standards of maintenance of irrigation systems influence water use and losses, as well as the reliability and costs of water delivery. Water savings techniques can only be introduced if water supply is reliable and predictable, so measures to improve reliability will in turn enable water savings. For this reason better maintenance is important. These factors may not all save water directly, but the indirect impact on water use as a result of better water management may be significant.

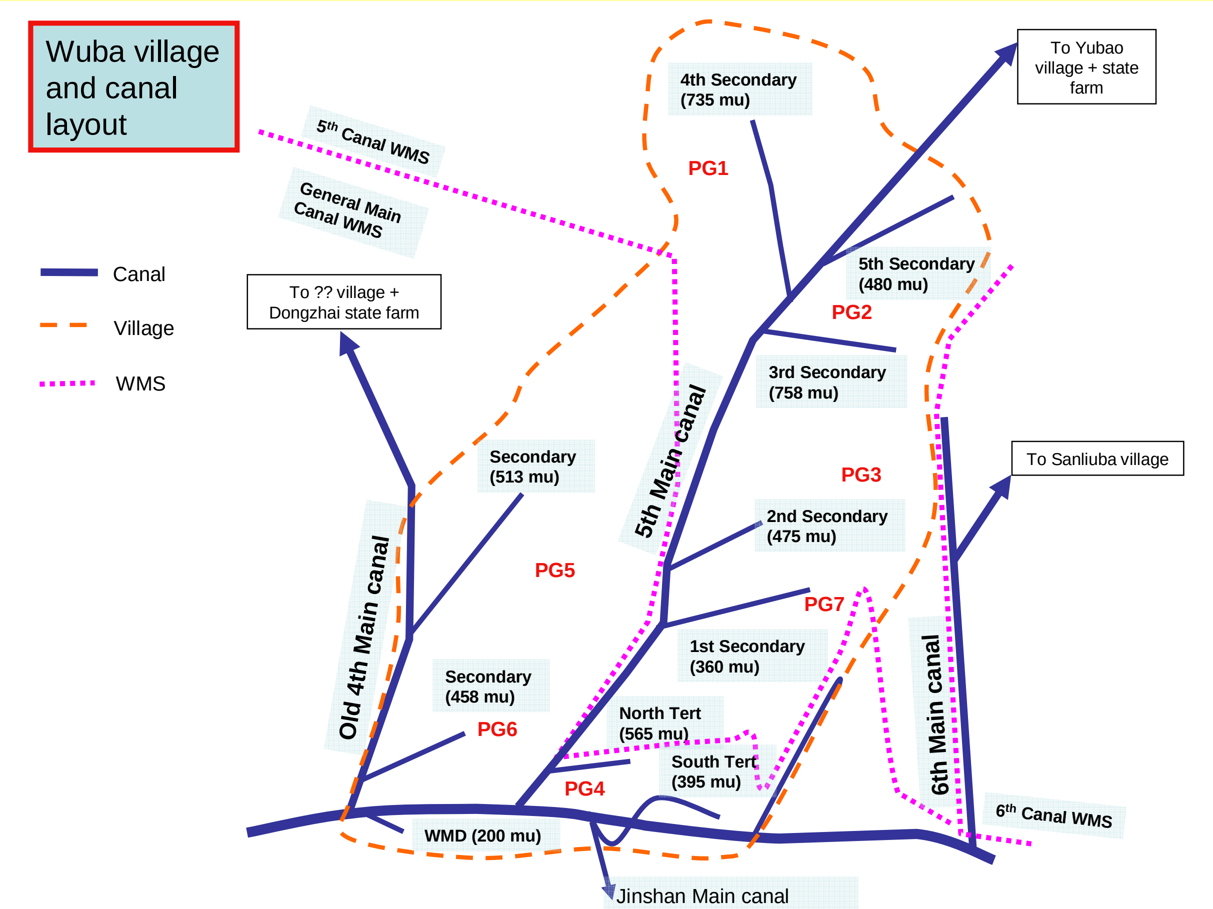
(i) Channel maintenance. It is important that canals are kept in good condition. Unlined canals need to be cleaned, vegetation removed, and leaks repaired. Leaks as a result of poor maintenance can lead to over-irrigation of some land and under-irrigation of others, while poor channel condition leads to weed growth and unproductive evaporation as well as impeded flow and channel overtopping. Poor maintenance affects the tail of the canal more than the head, but all farmers need to participate in maintenance activities (typically by cleaning the section from the previous farmer to their own plot).

(ii) Pump maintenance. Routine maintenance is needed to keep the pump running well and efficiently - breakdowns during the season disrupt irrigation potentially leading to crop damage, while poor condition leads to wasteful power consumption. Major repairs or replacements are more likely to be needed if routine maintenance is neglected.

(iii) Electricity supply. Problems with electricity supply are common but major problems are generally the responsibility of the electricity station. Poor wiring and switching at the pump, however, can cause disruption to operation as well as being a safety hazard. The installation of IC cards results in electrical controls being upgraded and made safer but, in the longer term, they too will need maintenance.

As noted earlier in Section 3, it is important that funds are collected to pay O&M staff, including production group leaders and well operators, so that they can undertake responsibilities effectively. These need to be paid by the farmers, and are distinct from the management charges and the water resources fee paid to the WMS. The cost should not be very high, and the magnitude and schedule of payments should be specified in the by-laws of the WUA.

Box 6: Irrigation scheduling in Donghe Irrigation District



The 5th main canal supplies water to two villages and a state farm, via about 15 secondary canals. The first village (Wuba) is illustrated in the schematic map above. The main canal operates almost continuously during the cultivation season, but all water is diverted into each secondary canal in turn so that each canal receives a high volume of water 3-4 times per year. It would be possible to change the schedule so that several secondary canals are operated together and thus receive smaller volumes of water on each occasion, but they receive this more frequently.

This is more complicated to manage (by water management stations, WUAs and farmers), as it requires measuring and controlling the flows into each canal and ensuring that each production group takes only the allocated amount of water, but it does make irrigation much more responsive to crop needs and thus more efficient. However, with the current cropping pattern and incentive structure there is little demand for such an approach: it will only become practicable if new crops are introduced, administrative regulation is made more stringent, and market conditions justify the change.

Canal lining

Canal lining is very popular with farmers as it can reduce the losses from their quota without requiring changes to the management systems. It can also simplify management. There are many alternative materials, and there is a need to optimise the design and construction of lining to maximise the economic returns.

In the short term, canal lining can reduce the need for maintenance– although in the longer term, maintenance of lined canals requires specialised skills and materials, and leakage through poorly maintained canals can be very high.

Canal lining from tubewell

Canal lining is often advocated as a means of saving water, but the overall impact of canal lining on actual water savings is rather controversial as much of the seepage loss from unlined canals returns to groundwater and is available for reuse (unless the groundwater is saline). Canal lining thus saves pumping costs more than it saves water. Some of the water is lost completely or wasted, but this is a small proportion of seepage losses (perhaps 10% of the losses). For example, lateral seepage from canals is used by adjacent crops – which thus receive slightly more than their allocation. This seepage may be a true loss if the adjacent land is fallow (path, field bund etc). True losses also occur by seepage or evaporation from the wetted perimeter of the canal after flows have ceased.

Although the impact of canal lining is small in terms of regional water savings, it does bring other benefits:

- It ensures the water availability per unit time is the same at the head and the tail of the canal – farmers at the tail would otherwise receive less water than those at the head.
- It is easier to control outflows to individual plots, as the outlets can be made to standard dimensions, and thus ensure that flow rates into plots are the same – this is important for equitable water sharing when more than one plot is irrigated at a time.
- It is easier to maintain (although more expensive once it starts to deteriorate some years after construction), and there are fewer losses through weed growth in poorly maintained channels.
- Reduced pumping costs (if applicable) and thus reduced electricity fees for farmers.
- For WABs, reduced conveyance costs for large scale transfers.

Given the benefits brought to individual farmers, there is a strong demand for canal lining. Providing lining is believed to be important to give an incentive to farmers to become more active themselves in other water savings activities. The cost of lining is reported to be about Y3,000 per km in materials, with a similar amount required in labour. Calculations from this indicate that costs of lining take a few years to recover from the savings made in pumping costs. Thus it is not surprising that production groups do not organise their members to line canals – unless they are given financial support..

Flow measurement infrastructure

Measuring irrigation flows does not directly lead to water savings but it is only possible to manage a water resource effectively if it can be measured. Flow measurement is also needed to establish whether water-saving interventions have been effective. More specifically flow measurement is required for four reasons:

1. monitoring compliance with permits for each abstraction point (or WUA);
2. ensuring that fees are calculated correctly;
3. ensuring equitable access to water (in accordance with rights and quotas to individuals);
4. instilling an awareness of flow rates and costs, and hence the value of water savings; and
5. quantification of water savings

Volumes of water pumped from the ground can be estimated to a sufficient degree of accuracy from electricity consumption, but the relationship between water use and electricity consumption needs to be calculated at least twice per season as there will be significant changes in groundwater level over the season.

Flow meters installed in the well and linked to an electronic recording device provide a direct and immediate record of volumes of water used from the well as a whole and by individual farmers. Pumped flow can also be measured directly using simple techniques such as pumping into a barrel of known volume and recording the time of filling.

Flumes, weirs or staff gauges can be used in canals to measure flows, but these need to be carefully installed and calibrated to ensure their accuracy.

Further details about the measurement of surface and groundwater use are outlined in Advisory Notes 2.6/1 ‘Groundwater Monitoring - River Basin to County Levels’ and Advisory Note 2.6/2 ‘Groundwater Monitoring at Village Levels’.

Weir in unlined channel

Table 2: Comparison of water savings interventions

Intervention	Cost	Funds	Ease	Effect-iveness	Accept-ability	Issues
Crop Structure change						
- Field crop	Low	Farmer	High	Depends on livelihood structure		
- Greenhouse crops	High	Subsidised	Med	High	Low - risky	Markets
Agricultural techniques	Med	Farmer	Med	Med	Low	Labour
Surface irrigation techniques	Low	Farmer	High	Med	Med	
New irrigation technology	High	Subsidised	Low	High	Low	High cost
Operation and maintenance of irrigation	Med	Farmer	Med	High	Med	

5 Social Change Tools – Participation and Awareness

It is widely accepted that the increased participation of farmers in water management activities would be beneficial for saving water; if farmers are involved in establishing and administering water management rules (eg. quotas, fees, schedules etc) they are more likely to adhere to them, allowing for increased efficiency and transparency in water delivery.

Such social change tools can have important impacts on water savings in several different ways.

Firstly, participation by all groups of users can help ensure that:

- user ‘rights’ are met;
- there is an understanding of policies, constraints etc; and
- the efficiency in water management is improved

Secondly, participation increases trust in the water management system, including in the approval and monitoring of quotas and permits (particularly where this leads to subsequent well restrictions or closure) and in the use of fees collected.

Thirdly, participation, awareness and understanding can help in persuading farmers to use less water than they would like, so that others (and the environment) can benefit and so that the limited resource can be protected for future generations

Lastly, wider participation in monitoring, communication and complying with rules can also help develop a common approach across the aquifer thereby avoiding the ‘tragedy of the commons’, where each individual takes more than is allowed because they feel that other farmers are doing so.

5.1 Participation, voice and democracy

The importance of participation in water management is reflected in the “Resolution on the Major Issues

Regarding the Building of a Harmonious Society" adopted at the Sixth Plenary Session of the 16th Central Committee of the CPC on Oct. 11, 2006 which focused on social development rather than political or economic development for the first time in China.

Key statements relating to community participation were that: "Social organizations should be promoted and their functions strengthened to serve society, including social service delivery, and relaying opinions and petitions of the citizens to expand the channels through which people can express their opinions easily". One year later, Mr. Hu Jintao further advocated the need for citizen's participation and democracy at the 17th National Congress of CPC on Oct. 15, 2007. Some of his statements are shown in Box 7.

Box 7: Building a "Harmonious Society"

Mr. Hu Jintao, 17th National Congress of CPC, October 15, 2007 said that we should:

"Expand socialist democracy and better safeguard the people's rights and interests as well as social equity and justice…" and

"…ensure that all power of the state belongs to the people, expand the citizens' orderly participation in political affairs at each level and in every field, and mobilize and organize the people as extensively as possible to manage state and social affairs as well as economic and cultural programs in accordance with the law… people's democracy is the lifeblood of socialism."

Other relevant documents include NDRC / MWR Document No. 2247 (2005) and MF / MWR Document No. 124 (2006) which indicate that WUAs should be set up whenever national funds are made available to support development of end irrigation systems.

These policies have important implications for the involvement of farmers in water management and thus for the establishment of farmer-owned Water User Associations (WUA). Firstly, the establishment and operation of WUAs is an important part of the reform of social administration and service provision in the area of rural irrigation water supply. Secondly, it is clear that WUAs are key platforms for farmers to assert their various rights, and can play important roles in the coordination of different interests, expression of appeals and requests, intermediation of conflicts and safeguarding of rights and interests as well as promotion of social harmony.

According to theses policies, the organizational structure and consultation procedures should take account of the rights of the poor and women. In addition, financial and administrative arrangements should suit the requirements of the WUAs, and should be set up in a way which will enhance their accountability and responsiveness. For example, the water fee collection should take account of the farmers' rights and interests (for example, payment of fees after harvest, rather than in advance) and it should be explicitly and accountably related to the operational costs of the WUA

There are several areas of water management where increased participation of farmers would be beneficial. These aspects are discussed in more detail in the following sections. In general farmers should be able to explain their needs and how irrigation fits in with other livelihood activities. They should understand the rules and responsibilities of different people, and where possible be involved in changing the rules.

5.2 Participation in management of canals and wells

Management of surface irrigation is complex, and WUAs can help considerably as is described in many reports, as described in various documents issued recently by MWR, and this is not repeated here.

However, groundwater irrigation has different requirements, and is not so well covered in the available documents. It is often assumed to be straightforward and within the capacity of traditional arrangements. In theory, farmers should be able to pump at times to suit their needs (subject to the limitations of quotas), but in practice irrigation schedules are often surprisingly rigid, with little farmer involvement in their development. This limits the individual scope for crop diversification and may even result in farmers using more water than they need. Conflicts can also arise if water is not delivered as required by the crop. For example, irrigation often follows a strict order (normally head to tail, with a standard time per mu), as decided by the production group leader. This is easy to administer if the cropping is uniform, but difficulties emerge at times of diversified cropping, especially at wheat harvest if wheat and maize are grown in the same area, as the maize requires irrigation while the wheat needs to remain dry.

In future cropping is likely to become much more diversified, as it becomes imperative to maximise the productivity of water which can only be achieved by growing small areas of a number of different high value crops in order to avoid over-saturating the market. This situation will arise gradually as norms and quotas are reduced, new well permits issued and enforced, leading to pressure to reduce water use but still maintain their income.

There will need to be effective participation in the design and implementation of crop zones and then of irrigation schedules to meet the needs of these crops and zones. This will ensure that farmer requirements are met, whist remaining within the constraints imposed by their ‘rights’ and the well permits.

5.3 Participation in abstraction and flow monitoring

Participation in monitoring water use is well-recognised to be effective in creating an awareness and understanding of the problems of water management (see for example van Steenbergen [2006]).

In areas irrigated by groundwater, participation in abstraction monitoring should extend across the irrigation district as it is important that farmers see that quotas and other water savings interventions are being applied consistently and fairly. There is no incentive for anyone to participate until quotas and other measures are seen to be enforceable and to be enforced. This requires a role by the village WUA to monitor compliance and publish results across the village, and the irrigation district WUA doing the same across the whole district or aquifer. The WMS should supervise the monitoring by WUAs and undertake its own less intensive monitoring across the township.

It is equally important to monitor surface water, and this can be more difficult. In some places dedicated measurement structures have been installed in canal. In other cases current meters are used, and most commonly, proxy indicators of flow volume, such as depth of water in fields are used. Not only is necessary to measure the flow rate (which may vary), but also the duration of irrigation should be recorded so that the total volume of water can be calculated.

Flow measurement training for farmers

5.4 Awareness of the need to save water resources

The rationale behind changing norms, introduction of water rights, reissue of permits etc is often not always fully understood. These may just be seen as an externally imposed requirement, not something which is ultimately aimed at helping the farmers. Farmers are usually concerned with maximising their short-term access to water, without too much concern for the sustainability of the resource. Their interest in reducing the volume of water they pump only extends to reducing their electricity costs. They are less concerned with overall water saving. Farmers seek assistance with canal lining to help them meet the norms and quotas, even if they are aware that this will not save water overall.

In addition, there is no willingness to save water until others are seen to be doing so – downstream users and even the needs of the next generation are discounted in this situation and few believe that individual or village level action can help resolve this problem. There is a need to get wider participation in and understanding of these issues. Imaginative awareness-raising programmes such as those organised by the Beijing Cultural Centre for the Development of Rural Women can help in fostering this better understanding.

Different approaches to water saving will be needed in different areas, according the severity of the shortage and the magnitude of savings which are being required or imposed. However, the limitations of voluntary measures must be recognised and adequate provision must be made for social protection and livelihood support.

5.5 Knowledge and understanding of fees

When new fees are introduced, or existing fees are increased, farmers often have little knowledge regarding why these are collected or what they are used for, and sometimes they get less assistance than they would like in return for the fees they pay.

It is important that the government department introducing the fees explains the reasons for the fee and assists in its collection. There is a general feeling that there should be greater accountability regarding the various fees paid to the government, with published accounts detailing amounts collected and used.

Local costs are usually managed by the production group leader, and some of these accounts are published. The WUA can play a useful role in overseeing the publishing of these local accounts to ensure accountability and consistency.

WUA and farmers calculating water charges

6 Incentives to Promote and Adopt Water Saving

Although farmers can reduce water use through agricultural techniques such as switching to more productive crops or land levelling, these improvements can be expensive, time consuming, and often require significant training. Thus a range of different measures are needed to encourage water users to save water, and to help them maximise their income with the reduced volume of water. This requires a combination of

- Administrative measures (regulatory controls)
- Financial incentives
- Technical skills and support
- Understanding of the needs for, and impacts of not saving water
- Cooperation and co-ordination

The details of how these can best be achieved in practice will vary according to local context, and thus the package of measures will need to be designed carefully. Total volume control, and targets to establish a water savings society are important, but probably not sufficient. Other activities are also required, but in each case the incentive (and disincentives) for carrying them out need to carefully assessed.

The focus of this document is on water use for crop production, but the same principles apply to water for livestock, fisheries and rural domestic use and more specifically to management of resources to meet all of these agricultural demands.

Although problems of quantifying water savings are referred to, this report focuses on techniques and incentives for saving water. Approaches for quantifying water saving and for auditing implementation of water savings societies are covered in other advisory notes.

"Take immediate action: save water"

7 Conclusions

This thematic paper provides an overview to methods for achieving water savings in agriculture. This follows the overall framework of management tools for IWRM and for water demand management given in other thematic papers:

- Assessment of resources and needs
- Options and interactions for IWRM
- Managing demand and supply (efficiency of water use)
- Social change instruments
- Conflict resolution
- Regulatory instruments

- Economic instruments
- Information management

The emphasis in this paper has been on five tools. These have been developed from the list above to apply them to the problems of agricultural water saving in North China. These are:

- Administrative measures (regulatory controls)
- Financial incentives
- Technical skills and support
- Understanding of the needs for, and impacts of not saving water
- Co-operation and co-ordination

These measures all need to be used in conjunction, as application of any single method is unlikely to be successful. Enforcement of quotas and permits will be essential, but these will just result in social hardship unless technical methods (agricultural training, improved irrigation management) are applied at the same time to help farmers cope with reduced water supplies. Even so additional mitigation measures (such as compensation for loss of land, or subsidies for greenhouses) may be needed in order to protect livelihoods.

Social change tools, including participation in all aspects of water management and related issues are important for ensuring that all farmers understand and adopt the recommended measures, and that the management tools are appropriate for the local context. These are important also for designing incentive structures to encourage farmers to save water.

Economic tools (water charges and resource fees) are not often very effective for demand management and should be used primarily as a means of recovering the costs of managing water, rather than for demand management, although it can be expected that better management of water will reduce its use.

In conclusion, it can be seen that achieving water saving is not easy, and will require a concerted effort by a wide range of stakeholders – and not just by the water users- using a variety of methods.

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WUA Water User Association

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Document Reference Sheet

Related materials from the MWR IWRM Document Series:

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Advisory Note 3.1/1	Agricultural Water Saving Techniques
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Advisory Note 6.2/1	Administrative Steps for Developing Strong WUAs
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Thematic Paper 6.3/2	Assessing the Impact of IWRM on Women’s Status and Conditions
Advisory Note 5.2	Formulation of Irrigation Service Charges for Surface Water Irrigation Schemes
Thematic Paper 5.3	Water Resource Fees

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**

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