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Irrigation Pricing Alternatives for Water User Associations in Central Asia¹

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Overview

The price of irrigation services provided by water user associations should be determined with three goals in mind: 1) Recovering the fixed and variable costs of providing the services, 2) Generating sufficient funds to maintain, repair, and replace durable assets, and 3) Communicating scarcity conditions in a manner that encourages all irrigators to use water efficiently. Given these objectives there are several pricing structures to consider. Perhaps the simplest is to divide the total costs of providing irrigation service, including the cost of water and the annual revenues required to maintain capital assets, by the area served, and to charge each farmer a fixed price per hectare, based on that calculation. This approach, known as area-based pricing, can achieve the first and second goals of recovering costs and generating funds for maintaining assets, but it will not communicate scarcity conditions or motivate efficient water use.

A variation of area-based pricing involves modifying the per-hectare charges to reflect the average amount of water delivered for irrigation of selected crops. For example, a water user association might assess a higher charge per hectare for land in cotton, than for land in wheat, given that farmers generally apply more water on cotton than on wheat. Such a variation provides a small incentive to choose crops that require less irrigation water, while retaining the simplicity of recovering irrigation service costs through a land-based assessment. However, the incentive effect can be quite small, particularly given substantial differences in the potential revenues earned by producing alternative crops.

A second variation of area-based pricing involves the combination of a charge per hectare of land with an allocation of water per hectare. If the amount of water available within a water user association is less than the sum of farm-level demands, the association might implement a per-hectare charge to recover fixed and variable costs, while also limiting water deliveries per hectare to each farmer. For example, each farmer might be required to pay an annual assessment per hectare, to secure delivery of no more than a clearly specified annual water allocation. Limiting water deliveries per hectare provides a strong incentive to use water efficiently, provided that the annual allocation is binding. That is, if the annual water allocation is the limiting input from the farm-level perspective, farmers will be encouraged to use their annual allocation efficiently.

Volumetric water pricing also will encourage efficient water use if the price per unit of water reflects all the costs of developing and delivering the water to farmers. In theory and in practice, when faced with volumetric water prices, farmers will consider the incremental farm-level cost of water and the incremental gains obtained from each irrigation event, when determining how much irrigation water to purchase. If water prices reflect all costs, then farm-level water use decisions will be efficient from both the farm-level and societal perspectives. Volumetric prices can be adjusted easily over time to reflect changes in the costs of providing irrigation services and changes in water scarcity conditions.

A volumetric water pricing strategy can be implemented in pure form or in combination with a per-hectare assessment. In a pure form strategy, all of the fixed and variable costs of providing irrigation services are reflected in the per-unit price of water delivered to farmers. This approach provides the strongest incremental incentive for using irrigation water efficiently. The primary

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disadvantage of the pure form strategy is that in years with limited water supplies or in years when farmers purchase less water than planned, a water user association might not generate sufficient revenue to cover all of its fixed and variable costs.

This disadvantage can be overcome by including both a fixed and volumetric component in the water pricing structure. Some or all of the fixed costs might be recovered through a per-hectare assessment on land, while some or all of the variable costs might be recovered through a volumetric water charge. In theory, such a mixed pricing strategy – known also as a two-part tariff – can increase the likelihood that a water user association will recover its fixed costs, while also providing a meaningful incentive for farmers to use water efficiently.

In this report, we consider the prospects of using these alternative pricing strategies for recovering the fixed and variable costs of water user associations in Central Asia, while also encouraging farmers to use water efficiently. We focus primarily on the use of volumetric water pricing and two-part tariff strategies, as these approaches provide stronger incentives for efficient water use than land-based pricing programs. We acknowledge that some water user associations might choose the simpler strategy of implementing land-based charges, yet we encourage all water user associations to consider pure form volumetric water pricing and two-part water tariffs. We note also that in addition to selecting an appropriate water pricing strategy, water user associations must ensure that farmers comply with association policies and remit the appropriate service charges, to ensure a high degree of revenue collection. Allowing farmers to receive irrigation water without full payment of the fixed and variable components of water charges will undermine efforts to achieve financial sustainability.

1. Irrigation Service Pricing Alternatives

1.1. Area-based Pricing

Area-based water charges are determined by dividing the sum of the fixed and variable costs of providing irrigation services by the total area irrigated. For example, if the total annual costs of operating a water user association, including the cost of water and appropriate charges for interest, depreciation, and investment is \$50,000, and the area served is 1,000 hectares, each farmer would be assessed a land-based, annual charge of \$50 per hectare. If revenue collection is successful, the water user association will recover all of its fixed and variable costs.

One disadvantage of this pricing strategy is the lack of an incremental pricing incentive that would encourage farmers to use water efficiently. Although farmers pay an area-based charge for irrigation services, the incremental price of water is zero. Thus, in theory, farmers will request a larger volume of water per hectare than they would request if water carried a positive incremental price. If water is scarce, the lack of an incremental price incentive can result in very inefficient water use, from both the farm-level and scheme-level perspectives. At the farm level, crop choices and irrigation volumes will not reflect the scarcity value that should be attributed to water resources. That is, farmers will not be encouraged to select crops that generate the greatest value with limited water. At the scheme level, irrigators at the head ends of some canals will over-apply irrigation water, while farmers at the tail ends of those canals will be unable to obtain sufficient irrigation deliveries.

Variations of area-based pricing strategies include assessing higher charges per hectare for crops that require more irrigation water. Such a program might influence farm-level cropping pattern choices in a small way, but it will not provide incentive to use water efficiently, as the incremental price of water remains zero. Another variation is to adjust the area-based assessments to reflect farm-level irrigation methods. For example, a water user association might assess a higher charge per hectare for crops irrigated with surface methods than for crops irrigated with sprinklers or drip

systems. This approach might influence technology choice to some degree, but still the incremental price of water is zero. In addition, the correlation between irrigation technologies and volumes delivered is not perfect. Many farmers can irrigate very carefully with surface methods, while many farmers over-apply irrigation water with sprinklers and drip systems.

Implementing water allocations in conjunction with area-based water pricing can provide sufficient incentive for using water efficiently, particularly if the allocations are binding and tradable. Binding allocations encourage farmers to make wise choices regarding cropping patterns and irrigation deliveries. Even with a zero marginal price, they will choose to apply water in ways that maximize incremental values if the total volume available is limited. Ideally, water allocations should be made tradable, so that farmers may purchase and sell portions of their annual water allocations within a water user association. Such a program would enable a farmer with a high-value crop requiring an additional irrigation to purchase water from a farmer with a lower value crop who might voluntarily choose to forego an additional irrigation. Binding water allocations motivate efficient water use at the farm level, while making those allocations tradable encourages efficient water use at the scheme level.

1.2. Volumetric Water Pricing

In its purest form, volumetric water pricing recovers all of the costs of providing irrigation services through the price charged per unit of water delivered. By design, this form of water pricing provides the strongest incentive for using water efficiently, as it involves the highest incremental water price. The water price is determined by dividing the sum of fixed and variable costs of operating a water user association by the volume of water delivered each year. The price can be adjusted over time as farmers and water user association staff members gain experience with farm-level responsiveness to volumetric water prices and with changes in the relative prices of farm inputs and outputs.

The conceptual advantages of a volumetric water pricing strategy are found in the simple notion that farm-level water demand is dynamic – rather than static. When faced with volumetric water prices, farmers will not rely on published irrigation norms or crop water requirements to determine how much irrigation water they should apply. Rather, they will request water deliveries that reflect careful consideration of incremental costs and gains. Farmer will consider how their crops will respond to each additional irrigation event, and the incremental values pertaining to those responses. They will consider also the role of other inputs in enhancing crop production and the implications for net returns. Ideally, all inputs will be priced volumetrically and farmers will be encouraged to make wise decisions involving the full range of inputs they use to produce crops and livestock products.

Volumetric pricing requires volumetric measurement and billing, and these can be achieved using high or low technology approaches. In modern irrigation districts, water is measured accurately using propeller meters in farm-level turnouts or similar meters placed in straight sections of water delivery pipes. Such methods are fine where meters are affordable, but lower technology approaches are equally valid. For example, water user associations can estimate water deliveries using water flow rates and delivery times or by reading staff gauges and calculating volumes delivered through carefully constructed delivery channels. The key criterion in establishing a volumetric measurement protocol is to ensure that farmers and water user association personnel agree that the measurement method will provide an acceptable level of accuracy.

A potential disadvantage of pure volumetric pricing is that revenues will fall short of the sum of fixed and variable costs in years when the water supply is limited or when farmers respond to volumetric prices by notably reducing the volume of water they request for irrigation. This potential problem can be overcome by enhancing the pricing strategy to include both a fixed charge and a volumetric component. For example, a water user association might include some portion of its fixed costs in an area-based charge, while including some portion of its variable costs in a volumetric price for water. Such a combined structure, known also as a two-part tariff, can increase the likelihood that

an association recovers its fixed costs, while also providing an incremental pricing incentive for farmers to use water efficiently. The board of directors or oversight council of each water user association can determine the precise allocation of fixed and variable costs between the two components of the two-part tariff.

Another variation of volumetric water pricing involves the use of increasing block-rate prices. The goal of such a program is to provide a strong incremental incentive to use water efficiently, while maintaining moderate water charges for farmers who do not over-apply irrigation water. This can be

Examples of two-part water tariff systems

Several OECD countries (for example Australia, Austria, Denmark, Finland and the United Kingdom) with successful water pricing schemes, use a two-part tariff structure. Examples of developing countries that have successfully used the two-part tariff are South Africa, Argentina, India and Singapore. This has fixed and variable elements. One of the main advantages of the two-part tariff system is the stabilised revenue base it affords the supplier. The fixed element protects the supplier from demand fluctuations and reduces financial risks. The variable element charges the consumer according to his consumption level and therefore encourages conservation.

Source: Rogers et al., 2002.

achieved by selecting volumetric prices that rise sharply with the volume of water delivered, beyond a targeted application rate. The following example describes how such a program might be structured.

Suppose a water user association wishes to encourage all farmers to use no more than 6,000 m³ of irrigation water per hectare of cotton. The association wishes to recover all of its fixed and variable costs, while also providing a persistent economic incentive for farmers to use water efficiently. An appropriate block-rate pricing structure might be the following. All farmers are required to pay an annual assessment of \$50 per hectare, which is determined by dividing the association's annual fixed costs by its service area. If the variable cost of delivering water to farms is \$10 per 1,000 m³, the association could implement a volumetric charge of that amount, or it could implement an increasing block-rate structure that includes two volumetric charges. The association might charge \$10.00 per 1,000 m³ up to delivery of 6,000 m³ per hectare, while charging \$15.00 per 1,000 m³ for deliveries in excess of 6,000 m³ per hectare.

Such a pricing structure would enable farmers to apply more than 6,000 m³ per hectare if they wish, but they would pay a substantially higher incremental price for those excessive water deliveries. Facing such a high incremental price, most farmers likely would choose to limit their water deliveries to 6,000 m³ per hectare. The empirical values of the parameters of a block-rate pricing structure can be adjusted over time, as water user association personnel gain experience with farm-level responsiveness to this pricing strategy.

2. Examples of Volumetric Water Pricing for the Ferghana Valley

To demonstrate the design of volumetric water pricing structures, we consider to illustrate in one water user association in the Ferghana Valley for this article: 1) Isan Water User Association in Kyrgyz Republic. We construct a two-part tariff pricing structure in which the fixed costs of operating the water user association are included in a per-hectare, land-based assessment and the variable costs are included in the volumetric water price. The data and pricing structures reflect empirical information collected from the water user association during 2009 and 2010. When evaluating farm-

level ability to pay for water services, we utilize farm budget information pertaining to crops produced in 2009 in each country (Appendix Table A10).

3. Isan Water User Association in Kyrgyzstan

The Isan Water User Association serves 2,032 ha of irrigated land in the Ferghana Valley of Kyrgyzstan. Currently, 475 farmers in 6 rural settlements belong to the association. Winter wheat and maize are the primary crops, while farmers also produce large areas of sunflowers, vegetables, and potatoes (Table 1).

The estimated aggregate irrigation requirement for 2009 in the Isan Water User Association, which reflects farm-level crop choices and water requirements for kitchen gardens, is 14 million m³ (Appendix Table A4). Assuming a farm-level application efficiency of 65% and a water user association delivery efficiency of 78%, the association must purchase 27.7 million m³ of water from the canal management organization (Appendix Table A4). The association plans to deliver 21.6 million m³ to farm turnouts. We use this volume, which represents an average farm-level delivery of 10,631 m³ per hectare, to calculate the volumetric component of the two-part tariff structure. By dividing all costs by the smaller volume of water delivered to farms, we ensure that the costs of water losses are recovered from farmers receiving water deliveries.

The planned budget of the Isan Water User Association includes both fixed and variable expenditures. The largest category of annual cash expenditures includes the salaries and benefits for year-round and seasonal employees. This category accounts for about 480,000 Kyrgyz Som, or about 45% of the annual budget (Appendix Table A5). To determine the fixed and volumetric components of the two-part water tariff, we first separate the annual budget expenditures into fixed and variable components. Fixed costs include the expenditures for year-round employees, administrative expenses, and depreciation. Variable costs include expenditures for seasonal employees, operational expenses, and contributions to the reserve fund. Variable costs include also the planned payments for water to the Aravan-Akbura Canal Management Organization. The association plans to purchase 27.7 million m³ for 380,000 Kyrgyz Som, for an average cost of 0.0137 Som per m³, or about \$0.32 per 1,000 m³ (1 USD = 43 Kyrgyz Som).

Table 1. Crop areas served by the Isan Water User Association, Osh, Kyrgyzstan, in hectares.

Crop	Area within the Association	Areas outside the Association	Sums
Winter wheat	345	138	483
Maize	316	143	459
Sunflower	241	5	246
Tobacco	75		75
Vegetables	225	110	335
Potato	124		124
Alfalfa, grass	55	37	92
Orchards	109	1	110
Kitchen-gardens	108		108
Sum	1598	434	2032

Given these assumptions regarding fixed and variable expenses, the planned annual fixed costs of the Isan Water User Association sum to 286,160 Kyrgyz Som (\$6,655), while the planned annual variable costs are about 790,942 Kyrgyz Som (\$18,394) (Appendix Table A5). Dividing the planned sum of fixed costs by the area served generates an annual fixed charge component of 141 Kyrgyz Som per hectare (\$3.28 per ha), while dividing the planned sum of variable costs by the expected volume of

water deliveries generates a volumetric component of 0.037 Kyrgyz Som per m³ (\$0.85 per 1,000 m³) (Appendix Table A6).

We consider the ability-to-pay for water on the part of Kyrgyz farmers by examining the proportions of total and net revenue that water expenditures would represent if the two-part tariff were implemented. We conduct our analysis for maize and wheat. Using data collected from farmers in the region (Appendix Table A10), we consider the total returns from maize and wheat production to be \$652 per hectare and \$832 per hectare, respectively, while the estimated net returns are \$340 and \$219 per hectare (Table 2). Given the fixed and volumetric components of the two-part tariff described above, average water service charges would range from 0.8% to 1.5% of total revenue in maize and wheat production, as farm-level water deliveries range from 4,000 m³ per hectare to 8,000 m³ per hectare (Table 2). Annual water charges would range from 2.0% to 4.6% of net revenue in maize and wheat production. We consider these ranges of proportional costs to be plausible and affordable for farmers producing maize and wheat.

Table 2. Scenario Analysis for Two-Part Water Service Charges Isan Water User Association, Osh, Kyrgyzstan

Ush, Kyrgyzstan

Pricing Assumptions:							
Fixed component		3.28		US Dollars per hectare			
Volumetric Component		0.85		US Dollars per 1000m3			
Crop revenue Assumptions:				Maize	Wheat		
Total Revenue (US Dollars per ha)				652	832		
Net Revenue (US Dollars per ha)				340	219		
				Maize		Wheat	
				Proportions		Proportions	
Water Delivery	Fixed Charge	Variable Charge	Sum of Charges	Of Total Revenue	Of Net Revenue	Of Total Revenue	Of Net Revenue
(m3/ha)	(\$/ha)	(\$/ha)	(\$/ha)	(%)	(%)	(%)	(%)
4,000	3.28	3.41	6.68	1.0	2.0	0.8	3.1
5,000	3.28	4.26	7.53	1.2	2.2	0.9	3.4
6,000	3.28	5.11	8.38	1.3	2.5	1.0	3.8
7,000	3.28	5.96	9.24	1.4	2.7	1.1	4.2
8,000	3.28	6.81	10.09	1.5	3.0	1.2	4.6

4. Discussion

Our analysis of the planned budgets of water user associations (here it means 3 WUAs, one from Kyrgyz Republic, one from Tajikistan and one from Uzbekistan) and the crop budgets of farmers in the Fergana Valley suggests that the costs of providing irrigation services can be recovered by implementing two-part tariff water pricing structures. The analysis suggests also that cotton, wheat, and maize farmers can afford to pay the fixed and variable components of those pricing structures, as the sums of these costs represent small portions of total and net revenues. While the fixed and variable components are reasonable, the two-part tariff structure will provide a financial incentive for farmers to manage water wisely, given that the farm-level annual cost of irrigation services increases with the volume of water delivered.

The planned costs of operating and maintaining water user associations, and the planned water volumes to be delivered each year, vary somewhat within the three associations we have examined. The planned fixed and variable costs, per hectare and per cubic meter, are highest in the Akbarabad

association in Uzbekistan, even though this association receives water at no charge from the government. The planned total cost of \$18.01 per hectare is about 50% higher than the planned cost in the Isan association in Kyrgyzstan (\$12.33 per hectare) and about twice as high as the planned cost in the Ovchi-Qalacha association in Tajikistan (\$8.57 per hectare) (Table 7). The notably higher planned cost in Akbarabad is due primarily to the large budget allocation for salaries and benefits, in comparison with the other associations. Planned expenditures for salaries and benefits are \$12.98 per hectare in Akbarabad, while Isan and Ovchi-Qalacha plan to spend \$5.51 per hectare and \$2.95 per hectare on salaries and benefits, respectively. The observed variation in planned expenditures for salaries and benefits suggests that some water user associations might be more efficient than others in providing water delivery services, although we have not yet examined the quality of services provided.

The volumetric charge for water delivered to farms also is notably larger in Akbarabad (\$1.23 per 1,000 m³) than in Isan (\$0.85 per 1,000 m³) and Ovchi-Qalacha (\$0.41 per 1,000 m³), due partially to Akbarabad's plan to spend a substantial amount on seasonal workers, and partially to the smaller volume of water delivered per hectare. The planned average water delivery in Akbarabad is 7,900 m³ per hectare, while average planned deliveries in Isan and Ovchi-Qalacha are 10,631 m³ per hectare and 14,119 m³ per hectare, respectively (Table 3). While the actual volumes of water delivered annually and the average costs are not yet known, the average cost of delivering water likely diminishes, to some extent, as the volume increases.

If the water user associations choose to charge for irrigation services using a pure volumetric tariff structure, the planned prices that would recover all costs would be \$2.28, \$1.16, and \$0.61 per 1,000 m³ in Akbarabad, Isan, and Ovchi-Qalacha, respectively (Table 3). Each of these volumetric prices is reasonable and affordable at the farm level, according to the farm budget information we have analyzed. We should note, however, that the Akbarabad association budget does not yet include a cost for water from the canal management organization. In addition, it is not clear that farmers in any of the water user associations would request the planned volumes of water if they were required to pay these volumetric prices.

As noted above, farm-level water demands are dynamic, rather than static. When faced with volumetric prices, farmers will consider the incremental costs and gains for each irrigation event and they will adjust their requests for irrigation water accordingly. It is this dynamic responsiveness that motivates consideration of pure volumetric and two-part tariff systems, with the goal of encouraging notable improvements in farm-level water management throughout the region.

Table 3. Comparing planned budgets, water expenditures, and two-part water tariff structures for three water user associations

Item	Units	Akbarabad Uzbekistan	Isan Kyrgyzstan	Ovchi-Qalacha Tajikistan
Irrigated area served	hectares	3,052	2,032	596
Planned volume of water inflow to WUA	m ³ / year	30,908,000	27,695,000	10,788,000
Planned volume of farm water deliveries	m ³ / year	24,108,000	21,602,000	8,415,000
Planned volume of water per ha	m ³ / ha	7,899	10,631	14,119
Planned annual fixed costs	\$ / year	25,380	6,655	1,661
Planned annual variable costs	\$ / year	29,590	18,394	3,449
Planned sum of fixed and variable costs	\$ / year	54,970	25,049	5,110
Planned fixed costs per hectare	\$ / ha	8.32	3.28	2.79
Planned variable costs per hectare	\$ / ha	9.70	9.05	5.79
Planned sum of costs per hectare	\$ / ha	18.01	12.33	8.57
Planned expenditures for water	\$ / year		8,837	1,674
Planned unit expenditure for water	\$ / 1,000 m ³		0.32	0.16
Two-part tariff analysis:				
Fixed cost component	\$ / ha	8.31	3.28	2.79
Variable cost component	\$ / 1,000 m ³	1.23	0.85	0.41
Sum of fixed and variable charges if farmers apply 6,000 m ³ per hectare	\$ / year	15.68	8.38	5.25
Proportion of total revenue (wheat)	percent	2.1	1.0	0.7
Proportion of net revenue (wheat)	percent	5.3	3.8	2.2
Pure volumetric pricing analysis:				
Volumetric price of water	\$ / 1,000 m ³	2.28	1.16	0.61

4.1. Limitations

The fixed and variable price components that result from our analysis reflect the planned budgets we have obtained from water user associations. Those budgets likely do not include all of the costs of operating and maintaining the associations each year, and also investing adequately in the maintenance, repair, and replacement of durable assets. Rather, it is likely that the budgets reflect a desire on the part of association managers to match their planned expenditures with expected revenues. Many water user associations post their planned annual budgets on the walls of their offices, in part to demonstrate transparency, and also to inform members of the relationship between the fees they pay and the services they receive. While both of these aspects are helpful and appropriate, the desire to show a balance between expected revenues and planned expenditures might lead some managers to exclude selected expenses from their planned budgets. Indeed, we learned of this practice during interviews with several association managers.

Among the expenses most likely to be omitted or under-estimated in the annual budgets are planned investments, depreciation, contributions to a reserve fund, and any costs that might be covered by the government if revenues from farmers are insufficient. While some of the associations include line items for depreciation and reserve funds, it is not clear if the amounts shown in those categories are adequate or if they reflect careful consideration of actual investment and depreciation schedules or risk management strategies. It is likely that many association managers have limited experience in financial planning. Yet they likely have accurate perceptions of the challenges involved in receiving full payment for water services from farmers. They might also have a good understanding of the government's willingness to provide monetary or in-kind support for water user associations when necessary.

Over time, water user associations will gain experience with financial planning and risk management strategies, particularly if capacity building efforts are continuously included in donor-funded projects to enhance the financial sustainability of water user institutions. As they gain experience, association managers and treasurers will begin developing long-term investment programs, in consultation with their councils, boards of directors, and other farmers. They will also begin assessing more completely the risks and potential problems that might arise during water delivery seasons, and they will develop meaningful strategies to create and maintain adequate reserve funds. With these developments will come more thorough consideration of the full costs of operating and sustaining water user associations. Those costs will then be reflected in long-term investment plans and annual budgets.

4.2. Extensions

The budgets and scenarios presented in this report demonstrate the potential viability of volumetric and two-part water service tariffs in recovering the costs of operating and maintaining water user associations in the Ferghana Valley. This work should be viewed as somewhat preliminary, as the budgets we have reviewed do not yet reflect all of the annual and long-term costs that water user associations should include in fully specified budgets. Additional work is needed to assist water user associations in gaining the capacity needed to develop long-term investment plans and to consider all of the costs that need to be collected from water users each year.

In addition to developing technical expertise pertaining to financial management, investment planning, and risk management, further work is needed also in establishing effective water user councils or boards of directors. The councils or boards should be comprised of association members who are elected to serve in those positions by the complete membership. Board members should be invested with full responsibility for ensuring the fiscal integrity and sustainability of the water user associations. They should be charged with hiring the water user association manager and approving all annual budgets and investment plans. The boards should meet monthly to review the association's

annual budget and approve current expenditures. One of the monthly meetings should be focused primarily on reviewing and approving the subsequent year's budget. The boards might consider forming a committee to work closely with the manager in developing each year's budget before it is brought to the full board for review and approval.

The board members of water user associations should choose pricing structures and determine empirical values of key pricing parameters, in consultation with association managers and members. The pricing structures in this report should be viewed as helpful examples of volumetric and two-part tariff pricing structures. The empirical values of fixed and variable components in our two-part tariffs arise from our division of annual costs into fixed and variable categories. Over time, board members might decide to modify their pricing structures or change empirical values, as they gain experience with farm-level responsiveness to alternative pricing programs. Many farmers will improve water management practices and change cropping patterns when they are required to pay for irrigation services, particularly if pricing structures include volumetric components. It is essential to continually assess the effectiveness of water pricing structures in achieving the three objectives of recovering the full costs of operating and sustaining water user associations, generating sufficient funds to maintain, repair, and replace durable assets, and providing the correct financial incentives for farmers to match their water management practices with water scarcity conditions.

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Appendix Table A4.**Crop water requirements for the Isan Water User Association,
Osh, Kyrgyzstan**

Crop	Indicators	Quantity	Crop	Indicators	Quantity
Winter Wheat	area, ha	483	Orchards	area, ha	110
	Water requirement (irrigation rate) m ³ /ha	6,400		Water requirement (irrigation rate) m ³ /ha	7,500
	Net water req., 1000 m ³	3,091		Net water req., 1000 m ³	828
Maize	area, ha	459	Alfalfa, Grass	area, ha	55
	Water requirement (irrigation rate) m ³ /ha	7,700		Water requirement (irrigation rate) m ³ /ha	11,800
	Net water req., 1000 m ³	3,531		Net water req., 1000 m ³	649
Sunflower	area, ha	246	Kitchen Gardens	area, ha	108
	Water requirement (irrigation rate) m ³ /ha	4,000		Water requirement (irrigation rate) m ³ /ha	
	Net water req., 1000 m ³	984		Net water req., 1000 m ³	1,708
Tobacco	area, ha	75	Vegetables	area, ha	335
	Water requirement (irrigation rate) m ³ /ha	8,500		Water requirement (irrigation rate) m ³ /ha	7,800
	Net water req., 1000 m ³	638		Net water req., 1000 m ³	2,613
Total in WUA	Sum of crop areas, ha	1,871			
	Net water supply to the field thousand m ³	14,042	Average water volume (m ³ per ha):		
	Field Application efficiency	0.65			
	Gross water supply to farms thousand, m ³	21,602	Average water volume (m ³ per ha):		
	Efficiency of the distribution system	0.78			
	Water intake in WUA thousand m ³	27,695	Average water volume (m ³ per ha):		

Appendix Table A5.

**Planned Budget for the Isan Water User Association in 2009,
Osh, Kyrgyzstan**

Item	Planned Expenditures, In Kyrgyz Som	Items	Subtotals	
1	Salaries of Personnel		391,200	
	Salaries for administrative staff	192,000		F
	Salaries for operating personal (seasonal workers)	199,200		V
2	Social Funds and Taxes		89,976	
	§ Social Insurance for administrative staff (19%)	36,480		F
	§ Social Fund for operating personnel (19%)	37,848		V
	§ Tax for administrative staff (4%)	7,680		F
	§ Tax for operating personnel (4%)	7,968		V
3	Administrative and Management Expenses		15,000	
	Travel	5000		
	Payment of Union of Canal Water Users	5000		
	Stationary	2000		
	Electricity cost	1000		
	Communication expenses	2000		
4	Water and Maintenance Expenses		410,000	V
	Repair of on-farm canals & cleaning	30,000		
	Payment for the water to Aravan-Akbura Canal Mgt Organization	380,000		
5	Depreciation		35,000	F
	Sum of annual cash expenditures		906,176	
	Sum of cash expenditures + depreciation		941,176	
	Reserve fund (15 % annual cash expenses)		135,926	V
	Sum of cash expenses, depreciation, reserves		1,077,102	

Subtotals of the Fixed and Variable Cost Components			
	Fixed Costs	286,160	
	Variable Costs	790,942	
	Sum of Fixed and Variable Costs	1,077,102	
Note: F denotes a fixed cost component, while V denotes a variable cost component in this analysis.			

Appendix Table A6.

**Calculating Water Service Charges in a Two-Part Tariff Structure,
Isan Water User Association, Osh, Kyrgyzstan**

	In Ky Som	In US Dollars
Fixed Costs (Ky Som / yr)	286,160	6,655 \$ per year
Variable Costs (Ky Som / yr)	790,942	18,394 \$ per year
Area served (ha)	2,032	3.28 \$ per ha, TFC
		9.05 \$ per ha, TVC
Water delivered (1,000 m3)	21,602	12.33 \$ per ha, TC
Fixed area charge (Som/ha)	141	3.28 \$ per ha per yr
Vol. water charge (Som/m3)	0.037	0.85 \$ per 1,000 m3
		1.05 \$ per acre-foot
Currency conversions are		
based on an exchange rate of: 43 Kyrgyz Som / US Dollar		

Appendix Table A10.

Farm-level crop revenue data collected from individual farms in Uzbekistan, Kyrgyzstan, and Tajikistan, 2009

Uzbekistan		Tot Rev	Net Rev	Net water
Wheat	Andijan	1,000.0	414.5	424.5
Data from individual		855.0	229.2	239.2
farms in 2009		819.0	322.0	332.0
		765.0	180.1	190.1
Means		859.8	286.5	296.5
Uzbekistan		Tot Rev	Net Rev	Net water
Wheat	Ferghana	636.0	304.1	314.1
Data from individual		755.2	359.2	369.2
farms in 2009		577.7	248.6	258.6
		524.4	234.7	244.7
Means		623.3	286.7	296.7
Uzbekistan		Tot Rev	Net Rev	Net water
Wheat	Ferghana	787.0	322.0	332.0
Data from individual		720.0	248.0	258.0
farms in 2009		773.0	308.0	318.0
		648.0	254.0	264.0
Means		732.0	283.0	293.0

Uzbekistan	Grand			
Wheat	Means	738.4	285.4	295.4

Tajikistan		Tot Rev	Net Rev	Net water
Cotton	Sogd	783.0	233.0	261.0
Data from individual		899.0	243.6	270.6
farms in 2009		803.0	277.5	302.8
		813.0	239.3	264.3
Cotton	Means	824.5	248.4	274.7

Tajikistan		Tot Rev	Net Rev	Net water
Winter Wheat, Sogd		781.4	245.9	270.3
Data from individual		747.1	220.1	245.7
farms in 2009		547.1	108.0	126.4
		834.9	278.1	303.6
Wheat	Means	727.6	213.0	236.5

Note:
The 'net water' values are net revenues adjusted by removing the charges paid to water user associations. We use these net revenues when examining the impacts of water charges on farm-level net revenues.

Uzbekistan		Tot Rev	Net Rev	Net water
Cotton	Andijan	1,155.0	324.1	334.1
Data from individual		1,193.5	393.6	403.6
farms in 2009		1,185.0	367.6	377.6
		1,053.0	203.7	213.7
Means		1,146.6	322.3	332.3
Uzbekistan		Tot Rev	Net Rev	Net water
Cotton	Ferghana	960.0	307.0	317.0
Data from individual		936.0	293.0	303.0
farms in 2009		1,100.0	239.0	249.0
Means		998.7	279.7	289.7
Uzbekistan		Tot Rev	Net Rev	Net water
Cotton	Ferghana	1,104.0	443.1	453.1
Data from individual		1,058.0	439.4	449.4
farms in 2009		702.0	63.5	73.5
		687.9	41.4	51.4
Means		888.0	246.9	256.9

Uzbekistan	Grand			
Cotton	Means	1,011.1	282.9	292.9

Kyrgyzstan		Tot Rev	Net Rev	Net water
Cotton	Osh	1,333.0	754.3	768.2
Data from individual		1,368.0	765.0	781.2
farms in 2009		1,341.0	694.0	711.3
		1,164.0	575.0	588.9
Cotton	Means	1,301.5	697.1	712.4

Kyrgyzstan		Tot Rev	Net Rev	Net water
Wheat	Osh	821.6	178.1	193.7
Data from individual		920.7	308.7	326.0
farms in 2009		808.3	145.2	162.5
		778.6	172.7	193.5
Wheat	Means	832.3	201.2	218.9

Kyrgyzstan		Tot Rev	Net Rev	Net water
Maize	Osh	791.0	393.0	407.0
Data from individual		515.0	227.0	241.0
farms in 2009		651.0	359.0	373.0
Wheat	Means	652.3	326.3	340.3