Chapter 10

Assessing alternative models for farmers’ ability to pay for irrigation water

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Abstract

To sustain public projects for irrigating agricultural crops over long periods requires expenditures for investment, operations and maintenance, and periodic rehabilitation. Governments have historically been the primary sources for financing these projects, but farmer beneficiaries are increasingly expected to contribute substantially toward recovering costs. Estimates of farmers’ ability to pay (ATP), or repayment capacity, for part or all of the costs of irrigation water supply facilities are useful in deciding on how much of these costs farmers can and should pay. Three alternative models for determining farmers’ ATP have been identified. In this chapter, we formalize these alternative models to defining “ability to pay,” evaluate them, and illustrate their strengths and limitations – both from theoretical perspectives and with an empirical analysis based on data from a case study in the Kyrgyz Republic. We find that in the study region, the alternative models yield significantly different estimates of ATP. The model that we regard as theoretically correct yields a significantly lower ATP than does the one embodying the implicit approach of study-area non-specialists and non-economists.

Keywords: Ability to pay; Charging; Cost recovery; Irrigation; Repayment capacity

1 Introduction

Throughout the world, irrigation of agricultural crops with surface water is mainly carried out in large public schemes or projects. They typically consist of networks of facilities for capture, storage, and conveyance of water from the point of capture to numerous individual farmers’ plots.
For their productivity to be sustainable over the longer term, these projects require substantial expenditures on initial development, recurrent operation and maintenance activities, and occasional major rehabilitation to avoid deterioration of structures and keep the technology updated. While financial arrangements to fund irrigation projects usually contemplate government and/or donor sources, farmer beneficiaries are increasingly expected to provide a substantial share of the costs. Cost recovery from beneficiaries will help provide funds for adequate current financing of the irrigation system, for retirement of loans that funded the investment, or for future public needs. Accordingly, assuring the sustainability of irrigation schemes typically requires some formal analysis on which to base the share of irrigation system financing that farmers can support (their “repayment capacity,” or so-called “ability to pay” (ATP)), versus the financing provided by government or donor agencies.

This chapter reports our conceptual and empirical evaluation of several alternative models that have been used to analyze and evaluate farmers’ ATP. Our analysis was in part motivated by experience with an Asian Development Bank-funded study of ATP in the Kyrgyz Republic (Asian Development Bank, 2007). A diversity of opinions on how to estimate ATP was observed among those involved in planning and carrying out that study. Below, we first develop a conceptual framework to distinguish alternative approaches, then apply this framework to a case study of a region in the Kyrgyz Republic and, finally, draw conclusions for future directions in assessing farmers’ repayment capacity.

2 Background and conceptual framework

In this section, we review the policy background and general economic framework for analyzing the recovery of costs of irrigation projects, introduce some terminology, and present a formal modeling structure for determining irrigators’ ATP.

2.1 Policy background

To begin, it is useful to recall O’Mara’s (1990) two polar perspectives on how public irrigation projects may be financed. One type he calls the fiscal autonomy model, which reflects the typical approach to other network services such as electricity or telecommunications. The fiscal autonomy model assumes the existence of a well-defined, specialized, and autonomous organization that supplies specified services to its clientele and is financed all or mainly by the payments of its clientele for services received. The second, polar approach is called the fiscal dependence model. It views governments, because of the special economic nature of agricultural production, as naturally choosing to intervene in the agricultural sector. Given the uncontrollable and unpredictable fluctuations of climate, weather and economy, and low short-run elasticities of both supply and demand for farm products, individual farm households tend to experience widely fluctuating output prices and incomes for reasons beyond their control.
Moreover, many water users are financially unable to pay the full cost. In addition to agricultural income maintenance and stability, food security and employment may be other policy concerns. In this view, irrigation is thought of as the only one among many governmental activities directed toward supporting and stabilizing the agricultural sector, and a considerable portion of irrigation financing is expected to come from public sources.

2.2 General economic framework

For discussions of repayment capacity, it is useful to distinguish among several important economic concepts: price, charge, value, and cost. Price generally refers to a monetary payment per unit volume (e.g., cubic meter) of water. In a market context, price reflects the willingness to pay (WTP) of the marginal buyer and the willingness to sell of the marginal supplier, so price and value are synonymous. In a nonmarket context, almost always the relevant situation in water policy evaluations, value usually means a synthetic estimate of beneficiaries’ WTP (also called a shadow price). Costs may refer to the outlays necessary to purchase some goods or services. More generally, they are the value of the opportunities foregone because of the commitment of resources to an activity, or sometimes the WTP to avoid detrimental effects. The economic theory of pricing in public sector contexts is mostly cost-based.

A further distinction is between determining what to charge for water and the economic valuation of water. In the context of water policy, charging (or tariff-setting) refers to the process of setting the monetary amount of costs to recover from water users for purposes of sustaining the supply agency and its tasks, with possible consideration given to providing incentives for water conservation and assuring supplies for the less well-off. Economic valuation, in contrast, is the application of nonmarket economic methods to determine the economic value, based on the concept of WTP for water services, for purposes of evaluating proposed management and allocation policies. Charging and economic valuation reflect the opposite sides of supply and demand forces, respectively, that lead to equilibrium for market goods and services. In nonmarket contexts, charging represents the important policy choice of how much of costs to recover, and how and from whom to recover them. Charging mostly reflects supply-side considerations, primarily those based on costs. Demand-side considerations, those related to WTP at varying quantities, are reflected in economic valuation processes. Economic valuation is a study of water users’ behavior and of what priorities people are expected to place on water management policies. In the context of water policy choices, nonspecialists sometimes incorrectly equate the observed price or charge with economic value. Valid selection of policy instruments regarding water must reflect both cost and value considerations, with the level of charges limited by the water users’ ATP, rather than being defined by it.

A rather extensive literature on financing, pricing, and cost recovery for irrigation water projects has emerged in recent years. These writings include Cornish et al. (2004), Dinar (2000), Molle and Berkhoff (2007), Sampath (1992),
Small and Carruthers (1991), and Tsur et al. (2004). Even so, relatively little attention has been directed at formally conceptualizing and measuring farmers’ ATP or repayment capacity, although exceptions (which will be discussed later) are found in Gittinger (1982) and Moore (1999).

A major consideration in setting up a plan for irrigation cost recovery is the organization and configuration of the irrigation water delivery system. The typical design, particularly in Asia, is for large numbers of smallholder farmers to be supplied by an extensive network of large publicly operated canals and smaller distributaries. The water distribution system is typically comprised of unlined earthen canals and ditches, which leak extensively and lack accurate measurement devices. Of the several potential methods or forms of charging for irrigation water, the most common one is area-based (Tsur et al., 2004). In this form, a flat annual charge is set according to the land area (e.g., in hectares) being irrigated. Area-based charges, however, are criticized for the lack of any incentive to conserve water by reducing the number of irrigations, changing the amount of water applied per irrigation, or changing to less water-intensive crops. The main alternative to an area-based charge is some sort of volumetric charging system. Such an approach, of course, requires some agreed-upon method of measuring volume and the capacity to monitor deliveries to each smallholder plot. Our study method is most applicable to the most frequently encountered case: area-based charging, but could be adapted to volumetric charging approaches with a more complex mathematical programming model.

2.3 General definition of ATP

In economic terms, ATP can be defined as the maximum amount a representative farmer can be expected to be able to contribute toward financing the costs of some specific plan to develop, operate, maintain, and/or rehabilitate irrigation infrastructure under assumed or forecasted technology, policy, and market conditions. This maximum amount the farmer can pay for water supply is the amount of income remaining after all the other resources have been paid (in the amounts required to draw them into production, measured by their market price or, for nonpurchased inputs, by opportunity costs). The concept of ATP is important in irrigation planning and cost recovery analysis because it provides an approach to establishing appropriate farmers’ shares of costs incurred in developing, operating and maintaining, and rehabilitating facilities for delivering irrigation water.

As will be shown below, this definition of ATP is similar – but not always identical – to the definition for WTP, the standard expression for economic benefits of producers’ goods in cost–benefit analysis.

2.4 Conceptual model of ATP

2.4.1 Basic model
To enhance the clarity of our discussion, we develop a more formal model of ATP. It is derived from the model of net economic benefits from irrigation, or WTP. WTP is conventionally based on the theory of the firm, which describes
the basic production-side decision-making unit in mainstream microeconomic theory. (The formulation adopted here is developed in more detail in Young (2005, Chapters 3 and 5) The firm is understood to be a legal entity (such as a proprietorship, partnership, or corporation) that owns some inputs (also called factors of production) and purchases others, transforming these inputs into outputs of goods or services. The standard model begins with a production function – a relationship that shows the maximum production that can be obtained from all possible combinations of given inputs at the given state of technical knowledge – that serves as the technical description of the firm. In symbols, the production function for irrigated crop production can be expressed as follows:

\[ Y = f (X_M, X_H, X_K, X_L, X_W, C, E) \]  

(1)

where \( X \) stands for the quantity of an input and \( Y \) refers to the quantity of an output. The subscripts \( M, H, \) and \( K \) refer to inputs that are typically purchased by the farm (in the theory texts, usually termed as “contractual” inputs) – where \( M \) is materials, energy, and equipment, \( H \) labor, and \( K \) (borrowed) capital. The capital and operating costs of the farm’s water distribution system (ditches, pipes, sprinklers, and the like, and the energy to operate them) are typically treated as part of the materials, energy, and equipment costs. The remaining inputs are assumed here to be owned or “noncontractual,” although some of them often may also be purchased. The owned inputs are specialized inputs, those whose prices, in reality, are determined after the fact by the outcomes of managerial decisions within the existing natural and economic environments, but in water valuation practice must be estimated \textit{ex ante} by opportunity costs. The subscript \( L \) refers to land, \( C \) to equity capital of the firm, and \( W \) to irrigation water. (Note that water is treated as one of the owned inputs.) \( E \) stands for opportunity costs of owned skills, management, technical knowledge, and entrepreneurial creativity.

This model is written to be as fully general as possible, although it may be overly complex for small farms growing staple crops in developing countries. We deem it important that the production function be described here in as much detail as possible. Part of our subsequent critique of some models for estimating ATP is based on the belief that such models are mis-specified, in the sense that some inputs are omitted, and therefore farmers’ costs are understated and ATP overstated.

For this general case, the firm is assumed to operate in properly functioning factor and product markets, and faces perfectly elastic supplies for factor inputs and perfectly elastic demand for its output, so that prices are known and constant.

Using what is called the “residual method,” we next move from the production function to the rent function for water. The term “rent” in economic theory differs from the meaning ascribed in everyday language; it refers to nonobservable income imputed to an input in limited supply. The residual method is used primarily for valuing nonmarketed producers’ goods (also called intermediate inputs). Given the “adding-up theorem” – which asserts that the sum of all the costs of inputs exactly equals the total revenue from production – the net producers’ rent attributable to a nonpriced productive input is found by subtracting all other estimated costs of
production from forecasted total value of output. That is, the remaining value is assigned to the nonpriced residual input, in this case, water.

In eqn (2), let \( R \) represent economic rents to the residual claimant, and the superscript \( W \) stand for water. \( P \) refers to the array of prices of outputs and factor inputs. By convention, the net rent formulas are usually standardized in terms of land, that is, expressed in per unit land (e.g., per hectare). Here, as is also typical, these formulas are expressed in annual (rather than present value) terms. Assuming input and output prices and production technology remain constant, and durable input costs are expressed in annual equivalent terms, the basic annual water-related rent formula for a single commodity can be written symbolically as follows:

\[
R^W = Y - [(P_M \times X_M) + (P_H \times X_H) + (P_K \times X_K) + (P_L \times X_L) + C + E] \tag{2}
\]

Typically, the non-water inputs amount to the major share in total value of output, and the calculated residual rent, while not trivial, is a relatively small portion of it. In consequence, the estimated residual can be very sensitive to changes in the non-water costs, and particularly sensitive to omissions of any cost components.

Note that this formulation represents a Marshallian long-run, partial equilibrium model. Our assumption of the long-run model, in which all factor inputs are assumed to be variable, is important to our results. Since it is assumed that each of the non-water inputs are paid their marginal value product, the rent formula represents the measure of a representative farm firm’s long-run WTP for water for a crop on a unit land area (Young, 2005, Chapter 5). (A pervasive challenge in estimating both WTP and ATP for irrigation water is that the non-water-owned inputs \( C \) and \( E \) in eqn (2) are often themselves nonpriced, and must be estimated by their opportunity costs or by rules of thumb.)

### 2.4.2 Alternative ATP models

ATP calculations are normally conducted as part of or as a follow-up of the economic benefit estimation in cost–benefit analysis of some plan or proposal to invest public funds for developing, repairing, or renovating an irrigation distribution network. We now show how the calculations for net economic benefit, or WTP, provide the basis for estimating ATP. Depending on the situation, ATP may or may not equal WTP for irrigation water. Consider three possible cases of interest:

**Model 1:** This case is based on the following assumptions: Farmers operate within properly functioning competitive factor and product markets. Specifically, opportunity costs of input factors – for example, labor, materials, or capital – equal their market prices. Further, social values of products equal their market prices. There is no public intervention into either factor and/or product markets. These assumptions are embodied in eqn (2), rewritten as eqn (3):

\[
WTP^W(1) = Y - [(P_M \times X_M) + (P_H \times X_H) + (P_K \times X_K) + (P_L \times X_L) + C + E] \tag{3}
\]
As defined earlier, ATP$^W$ refers to the maximum amount the (representative) farmer can be expected to be able to contribute toward financing the costs of some specific plan to develop, operate and maintain, and/or rehabilitate irrigation infrastructure under assumed or forecasted technology, policy, and market conditions. The net ATP equals the rents or returns available to pay for water after all other inputs are paid the amounts necessary to draw them into production. Thus, the Model 1 formula for ATP$^W$ is

\[
ATP^W(1) = (Y \times P_Y) - [(P_M \times X_M) + (P_H \times X_H) + (P_K \times X_K) + (P_L \times X_L) + C + E] 
\] (4)

The right-hand sides of eqns (3) and (4) are identical, both satisfying this definition. In other words, in an economic environment of properly functioning competitive factor and product markets, and where the economic analysts judge that no shadow pricing is needed in either factor or product markets, \(ATP^W(1) = WTP^W(1)\).

Model 2: The changed assumption for this case is that prices of one or more relevant factors and/or products are not determined in properly functioning markets. There may be public intervention into factor and/or product markets, a situation frequently encountered in the agricultural sector of many countries. In the cost–benefit analysis of these cases, one or more of factor and/or product prices have been obtained by shadow pricing. In the prototypical example of Model 2, the social opportunity costs of labor are estimated to be less than the market wage faced by farmers. Cost–benefit studies in developing countries with unemployed workers typically calculate social WTP with a shadow wage assumed to be less than the market wage. In the extreme case, the opportunity cost (shadow wage) of labor can be assumed to be zero. In eqn (5), letting \((P_H \times X_H)\) fall to zero, we have WTP$^W(2)$ as follows:

\[
WTP^W(2) = (Y \times P_Y) - [(P_M \times X_M) + (P_K \times X_K) + (P_L \times X_L) + C + E] 
\] (5)

Other things equal, for this example, the residual \(WTP^W(2) > WTP^W(1)\) by the amount that labor cost are reduced via shadow pricing. With farmers still paying the market wage for labor, the specification of ATP$^W$ is the same as in eqn (4):

\[
ATP^W(2) = (Y \times P_Y) - [(P_M \times X_M) + (P_H \times X_H) + (P_K \times X_K) + (P_L \times X_L) + C + E] 
\] (6)

Thus, reflecting differing assumptions about the market price versus social opportunity costs of some inputs, ATP$^W(2)$ differs from WTP$^W(2)$. In the above example, where the social opportunity cost of labor is estimated to be less than the market wage, \(ATP^W(2) < WTP^W(2)\).

Other examples of Model 2 arise when crop prices received by farmers do not reflect their social value. For example, in the United States, price support programs lead to prices faced by farmers being higher than their...
social value – as with cotton and wheat. Conversely, some developing countries have held crop prices down to favor urban interests, leading to crop prices that are less than estimated social values. The first of these instances leads to an $ATP_W(2) > WTP_W(2)$. The second instance leads to $ATP_W(2) < WTP_W(2)$.

Model 3: This case assumes a different formula for defining $ATP_W$. Within the economic/policy conditions of either case 1 or 2 above, for case 3, maximum $ATP_W(3)$ is assumed to equal “net farm income,” that is, returns to water and all other owned inputs. We have not come across any formal definition of $ATP_W$ of precisely this form in the literature. However, this case reflects the informal, intuitive concept non-economists and even nonspecialist economists proposed in our discussions of appropriate modeling of $ATP_W$ in the Kyrgyz Republic. This formulation is similar to models of private short-run farm decision-making (such as for annual crop land allocation) emphasized in textbooks on farm management (e.g., Kay et al., 2007), and thus is familiar to analysts trained in modeling private farm decision-making, but not necessarily familiar with social cost–benefit analysis. In this case, $ATP_W$ can be written as in eqn (7), where the residual is defined as revenue minus the costs of purchased inputs, $M$, labor, $H$, and borrowed capital, $K$:

$$ATP_W(3) = (Y \times P_Y) - [(P_M \times X_M) + (P_H \times X_H) + (P_K \times X_K)]$$

(7)

Thus, other factors unchanged, $ATP_W(3)$ is (much) greater than $ATP_W(1)$ and $ATP_W(2)$.

Our theoretical critique of $ATP_W(3)$ is straightforward: We find case 3 to be an incorrect estimation of repayment capacity since it would require farm households not only to pay for water out of the residual returns to water but to possibly draw from the returns to all owned inputs. It would be correct only if the opportunity cost or price of all non-water-owned inputs were zero. Put another way, this approach to calculating $ATP_W$ would – in addition to charging up to their total return to water – capture from farm households the return to some or all of their non-water-owned inputs. Economic theory suggests that if charges were set higher than $ATP_W(1)$, farm households would discontinue irrigated crop production.

2.5 Some additional issues

Space limits prevent more detailed analysis, but here we mention two other issues that arose in the Kyrgyz Republic study. First, non-economists were eager to consider the value of livestock production and even of off-farm income in the assessment of farmers’ repayment capacity. In our view, livestock operations are value-added enterprises that can exist largely independent of irrigation water, since feeds and forages for livestock production can, in principle, be purchased on the open market. The net return to water from feed and forage crops should already adequately reflect the contribution of irrigation water because forage crop outputs are valued using market prices, even though much of the production may be consumed on farm. Other on-farm enterprises, like clothing and handicrafts,
also have little or no direct link to irrigation water. Off-farm employment, remittances, and social security payments are nonfarm sources of income that have no direct connection to water supply, and should not be tapped to help recover costs of supplying water. A second issue is how to price land in the calculations. Since the formulation is in annual terms, an annual land rental rate rather than a sales price is appropriate. A readily observed land rental rate is that for irrigated lands. However, market rental rates already would include the contribution of irrigation (as well as the on-farm capital cost of developing irrigated land (such as provision for land leveling, ditches, turnout structures, and drainage). The rental rate on nonirrigated land of comparable quality and productivity would be the appropriate measure of opportunity cost of land.

2.6 Further remarks

We should acknowledge that the brief description and the simplifying assumptions in the above analysis may make the process of estimating ATP appear to be a simpler task than it actually is. Space limitations only allow a mention of some of the challenges, mainly associated with the uncertainties of operating the long-lived investments characteristic of irrigation development or rehabilitation that should be recognized in both the WTP and ATP assessments. For example, assignment of opportunity costs of noncontractual (owned) inputs in the ATP and WTP analyses is complex and often controversial. Crop production and water application technology as well as real product and input prices can be expected to change over time. Over the past several decades, the improvement in crop production technology has led to a more or less countervailing reduction in inflation-adjusted commodity prices, so that static annual models assuming no change in technology, prices, or net income have shown better predictive value than attempts to independently predict price changes and technology and yield changes. (Whether this sort of simplification will continue to be adequate in a context of global climate change remains an open question.) Another consideration is the shorter-term income uncertainty due to weather and markets. (In 1982, Gittinger dealt with this issue by including a “risk-bearing” function in the definition of the production function and suggesting a charge of approximately 10% of net farm income to account for this concern.) In the case of farms at the tail end of an irrigation distribution system, water supply per unit area tends to be lower and, because of inadequate water availability for leaching salts, crop-damaging salinization of soils is greater. Thus, a given farm’s location on the system has been shown to be an important determinant of water availability and crop production. If the charges analysis takes an average of head and tail incomes, the tailenders would be at a disadvantage.

2.7 Previous literature

As mentioned earlier, we found only a few efforts that directly addressed a conceptual framework for ATP. The World Bank has long emphasized enhancement of irrigation water supplies as an economic development tool in
semi-arid and arid low-income countries throughout the world. Irrigation was perceived to yield favorable economic returns on donor agency and water user capital, as well as to enhance food security and employment in impoverished rural areas. The World Bank doubtless has evaluated and financed more irrigated land developments than has any other agency. Gittinger (1982) codified the Bank’s procedures for evaluating agricultural projects and offered detailed descriptions of appropriate approaches to assessing cost recovery policies. In World Bank parlance (Gittinger, 1982; pp. 222–232, the calculation of what we call WTP\(^{(2)}\) is called the “economic analysis,” and the calculation of approximately what we term ATP\(^{(2)}\) would be considered to be “financial analysis.”

Moore (1999) studied a project of the U.S. Bureau of Reclamation in the Sacramento Valley in Northern California to measure farmers’ ATP for irrigation water. He provides a theoretical definition of the term that we interpret as equivalent to our ATP\(^{(1)}\) and WTP\(^{(1)}\). That is, Moore’s theoretical ATP is equal to estimated revenues less the cost of all non-water inputs, both contractual and noncontractual. With sophisticated econometric techniques, Moore fits a multi-output revenue function to 11 years of crop revenue, prices of major crops, areas of irrigated lands, and water delivery data from 19 irrigation districts that varied in water supply per acre. Comparing his measure of ATP with that of the water supply agency – the U.S. Bureau of Reclamation – Moore found that his method yielded a much larger estimate of ATP per unit area. Moore’s inductive method is exceedingly elegant and, to its credit, relies on real-world observations. However, it is ex post in the sense that it must take data from an ongoing system, rather than studying a proposed future investment. Thus, in contrast to the typical deductive approach, and the one used here, it is not adapted for sensitivity analysis. These considerations suggest that the method would find its application mainly in research contexts.

3 Case study from the Kyrgyz Republic

3.1 Background: Description of study area

The Kyrgyz Republic became independent from the Soviet Union in 1991. Located in Central Asia, the largely mountainous country is bordered by Kazakhstan to the north, Uzbekistan to the west, Tajikistan to the southwest, and China to the east. Irrigated agriculture is centered in the higher short-season Chui and Talas river valleys in the north and east, and in the hot subtropical Ferghana Valley in the southwest. Major crops are feed and forages for livestock, plus grains such as wheat and barley.

Since the 1990s, external donors have been assisting the government in rehabilitating the extensive irrigation systems, and even in meeting the cost of routine operations and maintenance. Only a small fraction of the total cost of sustaining the country’s irrigation systems has been met by charges assessed on farmers and other water users. It is increasingly recognized that the government needs to improve cost recovery from users, and that water user associations need
to recover more from their members to sustain the infrastructure within their borders. With financial assistance from the Asian Development Bank, a study was initiated in 2006 to analyze the ability and willingness of farmers to pay for irrigation and drainage services\(^1\) (Asian Development Bank, 2007).

The Sovzhnzy branch canal in Chui Oblast was among the study areas selected as part of the study to assess the long-term sustainability of the irrigation system and, more specifically, the farmers’ ATP and WTP for irrigation services. The Sovzhnzy main canal services 4200 ha of level land that is managed by eight water user associations in the short-season Chui River valley. The study area is west and north of Bishkek, the country’s capital.

3.2 Some preliminaries in the application of alternative models

As part of the study, representative farm budgets were constructed on the basis of a survey of farms within the Sovzhnzy study area. The survey was stratified to ensure enough observations of farms by size (smaller, medium, and large) and location on the delivery canal (head, middle, and tail). The 2005 crop year, for which crop budget data were collected, was considered to be normal in terms of yields and prices of major commodities.

Regarding the use of household labor, since formal surveys enquiring about this input are often difficult for farmers to answer (and likely to underestimate it), a smaller number of more informal and in-depth farmer interviews were also conducted. Management reflects the time spent by the owner/manager in planning and other activities not captured in the time spent in field production and harvesting activities. This was valued at 5% of the total value of output. Land was valued at its opportunity cost, which was assumed to be the rental cost of nonirrigated, but otherwise similar, agricultural land. With very little capital at the farm level, capital was valued at zero.

3.3 Application of alternative models

To illustrate the application of the three alternative models, we calculated ATP and WTP values as residuals from a representative crop budget of 1 ha. As necessary, this can be scaled up to the respective values for an average farm or the entire study area.

The total value of output represents yield of all crops in the Sovzhnzy study area (weighted by their proportion in the study area) multiplied by their output prices. It thus values all production whether actually sold or consumed on the farm or within the household. Given that crop prices in the Kyrgyz Republic are market-determined, with little government intervention, the total value of output is the same for the three models. Purchased input costs are also market-determined, and the same for all models. Costs for which the three conceptual models can lead to different values are those of labor, management, and land.

Table 1 shows estimates of WTP and ATP for water per hectare based on Model 1. This approach values all outputs and inputs at market prices. The estimated ATP\(^P\) (1) for irrigation services is US$198 ha\(^{-1}\), and equals the estimated WTP(1). All values are expressed in 2005 US$, using the conversion rate of US$1 = Som 40.
Table 2 shows the respective estimates for Model 2. WTP\textsubscript{2} is calculated with a shadow wage based on its social opportunity cost. Since there is a high level of unemployment and underemployment of labor in the Kyrgyz Republic that has existed since the economic collapse following the breakup of the Soviet Union, we chose as the opportunity cost for labor half of the market wage. No cost is attributed to management in WTP\textsubscript{2}. Gittinger (1982) argues that in the case of farmers who own their farms and supply most of both the labor and management skills, only wages as laborers should be valued, not management skills (though there are differences in opinion – see, e.g., Young (2005, Chapter 5). As a result, this estimate of the ATP for water is US$242 ha\textsuperscript{-1}, which is 22% greater than estimated by the model of ATP\textsubscript{1}.

Table 3. WTP\textsubscript{3} is assumed to be equal to WTP\textsubscript{2}. For ATP\textsubscript{3}, net farm income (essentially, return to farm-owned inputs) is the concept representing this version of the farmer’s maximum ATP for water. The cost of farmer-owned inputs, including household labor, management, and land, are in this case valued at zero. This leads to an estimated ATP of US$268 ha\textsuperscript{-1}, or 36% higher than ATP\textsubscript{1}, and also higher than WTP\textsubscript{3}.

Table 1: Estimates for Model 1.

<table>
<thead>
<tr>
<th></th>
<th>WTP\textsubscript{1}</th>
<th>ATP\textsubscript{1}</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total value of production</strong></td>
<td>381</td>
<td>381</td>
</tr>
<tr>
<td><strong>Cost of production</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seed, fertilizer, herbicides</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Contracted services – labor</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Contracted services – fuel</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>Transportation</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Hired labor</td>
<td>17</td>
<td>17</td>
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<tr>
<td>Household labor</td>
<td>14</td>
<td>14</td>
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<td>Management</td>
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<td>19</td>
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<td>Land cost</td>
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<td>Miscellaneous</td>
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<td>3</td>
</tr>
<tr>
<td><strong>Total cost of production</strong></td>
<td>183</td>
<td>183</td>
</tr>
<tr>
<td><strong>Residual</strong></td>
<td>198</td>
<td>198</td>
</tr>
</tbody>
</table>

*Note: WTP\textsubscript{1} = ATP\textsubscript{1}.*

### Table 2: Estimates for Model 2.

<table>
<thead>
<tr>
<th></th>
<th>WTP(W(2)) (US$ ha(^{-1}))</th>
<th>ATP(W(2)) (US$ ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total value of production</td>
<td>381</td>
<td>381</td>
</tr>
<tr>
<td>Cost of production</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seed, fertilizer, herbicides</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td><strong>Contracted services – labor</strong></td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Contracted services – fuel</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>Transportation</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td><strong>Hired labor</strong></td>
<td>9</td>
<td>17</td>
</tr>
<tr>
<td><strong>Household labor</strong></td>
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<td>14</td>
</tr>
<tr>
<td><strong>Management</strong></td>
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<td>19</td>
</tr>
<tr>
<td>Land cost</td>
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<td>38</td>
</tr>
<tr>
<td>Miscellaneous</td>
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</tr>
<tr>
<td>Total cost of production</td>
<td>139</td>
<td>183</td>
</tr>
<tr>
<td>Residual</td>
<td>242</td>
<td>198</td>
</tr>
</tbody>
</table>

*Note: WTP\(W(2)\) > ATP\(W(2)\) (with ATP\(W(2)\) = ATP\(W(1)\)).

Cost items that are shadow priced and thus differ from those in Model 1 are italicized.


### Table 3: Estimates for Model 3.

<table>
<thead>
<tr>
<th></th>
<th>WTP(W(3)) (US$ ha(^{-1}))</th>
<th>ATP(W(3)) (US$ ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total value of production</td>
<td>381</td>
<td>381</td>
</tr>
<tr>
<td>Cost of production</td>
<td></td>
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<td>7</td>
<td>0</td>
</tr>
<tr>
<td><strong>Management</strong></td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
We find that estimated ATP in the study area using what we believe to be a conceptually correct formula (our $\text{ATP}^{W}(1)$) is considerably higher than the amounts farmers have actually been charged, and would thus justify some increase in farmer contributions; but it is rather less than local and donor officialdom (implicitly using our $\text{ATP}^{W}(3)$) had believed. Casual observations elsewhere in the world suggest that this situation is rather typical, so that ATP would tend to be lower than that assumed by non-specialists and non-economists.

### 4 Conclusions

ATP is an estimate of the maximum that farmers could afford to pay for irrigation services. Political realities suggest that it is unlikely that the government would wish to extract the entire ATP from smallholder farmers. Overestimating ATP would give irrigation districts, governments, and lending agencies an exaggerated perception of the amounts that farmers would be able to pay for services.

Comparison of the three models to estimating ATP, captured in Tables 1–3, shows that substantial differences in estimates are produced under the different models. The appropriate model for estimating ATP is Model 1. Valuing inputs and outputs at social opportunity costs may be an appropriate approach to take in a cost–benefit analysis, but carrying this approach over into ATP can lead to misleading high estimates. Similarly, returns to all farm-owned inputs is a valuable concept in short-run farm management studies, but using this approach to value long-run ATP for water alone also leads to excessively high estimates.

Thus, analysts calculating ATP need to give careful attention both to the theoretical model on which the calculations are based and to the economic and production conditions relevant to the calculations.

### Endnote

References


