Report for 2002HI2B: A Win-Win Approach to Water Pricing and Watershed Conservation

- Articles in Refereed Scientific Journals:
    - Kaiser, B.; J. Roumasset, 2002, Valuing indirect ecosystem services: The case of tropical watersheds, Environmental Economics and Development 7, 701-714.
    - Pitafi, B.; J. Roumasset, Sequencing watershed conservation and groundwater management reforms, Journal of the American Water Resources Association, forthcoming.
    - Pitafi, B.; J. Roumasset, Pareto-improving water management over space and time: The Honolulu case, American Journal of Agricultural Economics, in revision and resubmission phase.
- Water Resources Research Institute Reports:
    - Kaiser, B.; W. Matsathit; B. Pitafi; J. Roumasset, 2003, Efficient water allocation with win-win conservation surcharges: The case of the Koʻolau watershed, Working Paper, Water Resources Research Center, University of Hawaii, Honolulu, Hawaii.
    - Pitafi, B.; J. Roumasset, 2005, Integrated water management policies for Oahu, WRRC Bulletin, Water Resources Research Center, University of Hawaii, Honolulu, Hawaii.

Report Follows

Problem and Research Objectives

Several studies have documented that inter-temporal water allocation in Hawaii is inefficient. However, the consequences of misallocation, including the economic value lost, are unknown. In addition, proposals for efficiency pricing have often been found to be politically infeasible because current users will have to pay a higher price even though future users will be better off. Moreover, other sources of mismanagement, including spatial misallocation and under-maintenance of watersheds, need to be considered in an integrated framework in order to assess the nature and size of the problem and the potential gains from policy reforms.

The overall objective of the project is to combine existing hydrological, engineering,, and economic knowledge in order to estimate efficient water use on Oahu. Pricing schemes for achieving efficient use are calculated. We show how efficiency pricing can be rendered politically feasible by compensating the users suffering a loss due to higher prices. Finally, rather than take aquifer recharge rates as exogenous to water management, we incorporate watershed management as one of the policy instruments.

Methodology

We estimate optimal groundwater usage with and without the watershed conservation plan. The modeling framework constructed estimates optimal groundwater extraction quantities while avoiding over-extraction that would lead to salinity in existing wells and using desalted water as supplemental source as warranted by demand. A hypothetical social planner chooses the extraction rate of water from the aquifer to maximize the present value of net social surplus. The dynamic of the head level is governed by the amount of water inflow, leakage, and extraction rate. We allow different discount rates, demand growth rates, usage at different elevations with different distribution costs, and different changes in forest recharge levels. The effects of watershed conservation are introduced in the form of probabilistic changes in recharge.

Principal Findings and Significance

We have constructed modeling frameworks, estimated parameters for each aquifer, and conducted pioneer simulations for the cases of Pearl Harbor and Honolulu aquifers.

The Pearl Harbor Case

We investigate the economic benefits of conserving a forested watershed in conjunction with efficiency pricing of the downstream groundwater resource. We find that under a wide range of parameter assumptions, investment in watershed conservation will generate positive benefit-cost ratios, even before accounting for biodiversity and other conservation benefits.

We examine the value of conservation of a forested watershed, assuming that watershed degradation occurs with low probability (between 1% and 20%). We start by describing the impacts of a certain loss of forest quality and associated recharge. If 31% of recharge from the Koolau mountain watershed area on Oahu is lost, this will decrease recharge to the Pearl Harbor aquifer by 15% and decrease the present value of the aquifer by more than $1.2 billion, assuming a 3% social discount rate and efficient resource use.

We then adapt the methodology used to determine this definitive loss in order to calculate the expected loss in social welfare from an uncertain probability of forest quality degradation. Assuming a modest probability of 10% that the resource is degraded, reducing aquifer recharge 15% after 20 years, we find that the expected benefits of conservation are $89 million using a 3% discount rate. This figure is robust to a large number of parameter changes. This estimate assumes that the resource manager optimally solves the problem of water extraction under uncertainty and knows that the optimal price path is discontinuous and jumps up or down after the event or nonevent is realized. In the likely event of mismanagement, inasmuch as water managers are typically unfamiliar with economic optimization even under certainty, the gains of conservation will be larger.

Policymakers have indicated that the costs of successful conservation may be as high as $45 million. Even at such high costs, conservation combined with efficient water management is a win-win-win situation for consumers, taxpayers, and the environment, albeit in the sense that the environmental insurance acquired through conservation costs less than its expected value. Only in cases where the probability of the event is very low do the estimates of expected social loss fall below $45 million.

In addition, we have compared the effects of efficiency pricing and watershed conservation. Efficiency pricing yields a welfare gain of about $900 million in present value, whereas watershed conservation yields only about $43 million without efficiency pricing and $45 million with efficiency pricing. Thus a watershed conservation that costs $45 million may be welfare-reducing if efficiency pricing is not undertaken simultaneously. We also find that if watershed conservation is adopted first, followed by efficiency pricing several years later, the delay can result in major losses (24 % and 44 % for 10- and 20-year delays, respectively).

The Honolulu Case

We analyze two scenarios of water usage/pricing. (a) *Status-quo pricing* — We derive the extraction rates dictated by demand resulting from continuation of the current pricing (equal to cost) and estimate resulting welfare. (b) *Efficiency pricing* — This is a scenario in which insufficient conservation efforts cause the risk of reduced recharge.

We find that if the status-quo policy of pricing water at average (extraction and distribution) cost is continued, consumption will grow quickly and the groundwater aquifer will be depleted fast (in about 57 years), with the head level reaching the minimum allowable (to avoid salinity). After that, extraction of groundwater cannot exceed the recharge rate. Any excess demand at that time and any future growth in demand must be met using the more-expensive desalination technology. Status-quo pricing does not differentiate users by distribution costs and results in subsidies from lower-elevation users (with lower distribution costs) to higher-elevation users. Efficiency pricing requires a slight price increase in the first year. This price rises smoothly over time, but faster than the status-quo price, until the aquifer reaches the minimum allowable head level and desalination has to be used (in year 76). As the efficiency price includes category-specific distribution cost, it avoids distribution-cost subsidies from lower- to higher-elevation users.

The efficiency-pricing regime is compared to status-quo pricing in terms of welfare. Since the efficiency prices are higher than the status-quo prices, initially users lose welfare by switching from status-quo to efficiency pricing. This is not true for the users in the lowest-elevation category who actually gain welfare because they do not have to subsidize the distribution cost of the higher-elevation users. Since most of the consumption occurs at the lowest elevation, these gains are substantial. Over time, however, as the efficiency prices rise, all categories see increasing losses relative to status-quo pricing (the present value of all losses is estimated at $34 million). Later, efficiency pricing becomes welfare-superior to status-quo pricing and remains superior afterwards because the status-quo policy would require the use of expensive desalination technology sooner and would rely on it more heavily than efficiency pricing. Thus efficiency pricing provides greater welfare to users in all elevation categories later on (the present value of the gains is estimated at $441 million).

Switching to efficiency pricing causes some (mostly high-elevation and near-term) users to lose welfare and some (mostly low-elevation and future) users to gain. The resulting political problems can be avoided by actually compensating the losers. This is achieved by proposing a compensation system for welfare-losing users through a free block. The cost of the free block is financed by the users who gain welfare in spite of this reduction. Efficiency pricing is thus made actually Pareto-improving by compensating those who lose welfare due to the switch from status-quo pricing.