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On the Natural and Economic Difficulties to Fulfilling the Human Right to Water

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Abstract

We present, to the best of our knowledge, the first economic model of the human right to water using a nonrenewable resource model inclusive of a backstop technology. The right is interpreted as a minimum consumption requirement the government is obligated to fulfill in the event that any one household cannot do so independently. Differing by income levels, households maximize utility by purchasing a composite consumption good and water from two distinct, government-owned sources. Facing physical and financial constraints, the government uses fiscal policy to address potential human rights violations. Reducing the analysis to two-periods, we develop a novel approach to compare total welfare levels from a joint human rights and economics perspective. We define a human rights welfare standard and discuss cases where traditional social welfare measures would meet, surpass, or violate this standard. We thus offer a unique way to merge economic analysis with human rights research.

1 Introduction

History has seen its share of conflict associated with water scarcity and accessibility.[1] From 3000 BC to 2010, the Pacific Institute counts 225 *water conflicts* resulting from control of water resources, terrorism, and religious, military, political, and economic differences. Today, the United Nations notes that 894 million persons lack access to a minimal amount of safe drinking water and 2.5 billion persons lack access to basic sanitation. Furthermore, water and sanitation related issues lead to the death of 1.5 million children under the age of 5 every year and the loss of 443 million school days.[2] Though perhaps surprising, these problems traverse economic boundaries, affecting both developing and developed countries.

Shah et. al. (2000) report that in the Saurashtra coast of Gujarat, India, excessive groundwater extraction in the 1960s and 1970s initially generated economic prosperity but eventually led to a collapse of the local economy. While some residents were able to secure off-farm jobs or relocate, many were forced to remain behind and suffer through a stagnant local economy. In the United States in 1980, the Arizona Department of Water Resources enacted the Groundwater Management Code to address groundwater overdraft and the effects overdraft can have on prosperity and quality of life. Wescoat Jr. et. al. (2007) note that water related poverty is also a problem in various urban, rural, and mountainous regions of Colorado, despite the claims that 100% of the US population has access to an improved water source.

In an effort to counteract the socially and economically damaging effects of water scarcity and accessibility, the world has seen a significant increase in the number of international, national, and regionally legally binding and non-legally binding instruments which recognize a human right to water either directly or indirectly (Herz, 2000; Hiskes, 2010; Scanlon, Cassar, & Nemes, 1999). More importantly, in the Summer of 2010, the United Nations General Assembly passed a resolution explicitly recognizing the human right to water and sanitation.[3] Furthermore, ten national constitutions include a direct human right to water as of 2010, and 125 include an environmental human right or at least the foundations of one (Jeffords, 2011).[4] The human right to water is clearly gaining legal momentum in the international community, however the extent to which governments can feasibly instantiate a justiciable human right to water remains woefully under-researched, especially from an economics perspective.

General Comment 15 of the United Nations Committee on Economic, Social, and Cultural Rights, outlines various aspects of the right as implied in Articles 11 and 12 of the International Covenant on Economic, Social, and Cultural Rights (ICESCR). Section II.12 discusses availability, quality, and accessibility concerns while Section III denotes government obligations to respect, protect, and fulfill the right. These obligations, often referred to as duties or obligations of conduct, delineate the role of government in preventing rights violations, adjudicating rights violations, and providing for the substance of the right. In order to meet obligations of conduct, the progressive realization section of Article 2 of the ICESCR notes that,

> Each State Party to the present Covenant undertakes to take steps, individually and through international assistance and co-operation, especially economic and technical, to the maximum of its available resources, with a view to achieving progressively the full realization of the rights recognized in the present Covenant by all appropriate means, including particularly the adoption of legislative measures.

In a world with limited freshwater supplies and a universal human right to water, the notion of *available resources* has to be extended to include natural or physical resource constraints.

Certain types of water, such as groundwater, are often considered depletable, even exhaustible (Shah, Zilberman, & Chakravorty, 1995). Economic theory dictates that, in the absence of mitigating factors, the price of an exhaustible resource will rise as the stock is depleted (Gray, 1914; Hotelling, 1931). As such, groundwater extraction can become increasingly expensive over time, a burden that regressively affects poorer income groups. The availability of a relevant *backstop technology* (Nordhaus, Houthakker, & Solow, 1973), such as desalinized or bottled water, offers a limit on the rising price of groundwater but itself could still be too high to afford. While scarce physical resources imply higher resource prices and therefore more stringent economic constraints, it would be difficult to acquire freshwater if stocks were fully depleted and alternative water technologies were not available. Therefore any attempt to implement the human right to water must also consider the relevant technology available to supplement exhausted stocks.

Humans require a certain amount of water to live, and the human right to water should be defined taking at least this minimum quantity of water into consideration. Relying on data from various sources including the World Bank, World Health Organization, and United Nations International Drinking Water Supply, Gleick (1998) defines the human right to water as a minimum consumption requirement of 13.2 gallons of water per person per day for domestic or residential use, inclusive of drinking water (10%), sanitation services (40%), bathing (30%), and food preparation (10%).[5] Following Stone (1954) and Geary (1950), we operationalize the human right to water as a minimum consumption requirement the government is obligated to respect, protect, and fulfill in the event that a person (or household) cannot do so independently. To our knowledge, this is the first paper to explicitly model the human right to water within the environmental and resource economics literature, and the broader economics literature in general.

As noted above, implementing the human right to water could occur through constitutionalization. Alternatively, the use of government policy, or a combination of constitutionalization and government policy are also options.[6] However, well-meaning governments are not always able to fulfill human rights obligations, in which case the responsibility to do so could fall on the international community. In this sense, other countries are said to have *extraterritorial obligations* to the people of the country experiencing failing human rights fulfillment or increasing human rights violations (Skogly & Gibney, 2007). Aid could come in the form monetary resources, or the provision of physical resources, such as bottled water or the technology for desalinized water. The main problem, however, is that if a government is unable to afford to provide water to its citizens for a lack of a sufficient resource base, then it is unlikely to finance any loans without serious consequences to the national economy. This presents an additional constraint on provision at home as the international community may be leery of providing no-strings attached funding, despite the concerns for humanity.

As water resources become increasingly scarce, driving water conflict issues in developing and developed countries alike, a pertinent question to ask is: Does adding the additional constraint of the human right to water alleviate any of these problems and to what extent do the physical and economic realities permit fulfillment of the right? To answer this question, we embed the right in an infinite time period nonrenewable resource model with a backstop technology where a poor and rich household allocate their respective incomes to purchase two goods: water and a composite consumption good.[7] As the price of groundwater rises, approaching that of the backstop technology, households face the possibility of being unable to afford both goods. If any one household can no longer afford to purchase its minimum water requirement, there exists a government whose sole responsibility is to enact a fiscal policy (i.e., tax and subsidy) to ensure the minimum is reached.[8]

Interpreting the minimum consumption requirement as a government obligation provides a tractable way to demonstrate fulfillment difficulties. We define a human rights welfare standard for each household based on this minimum, and shorten the model to two periods to analyze welfare levels within a joint human rights and economics framework. The welfare analysis illustrates cases where the human rights standard is exceeded, violated, or just fulfilled. In one case, the economic prescription is that only the rich household survives while the human rights prescription is for both the poor and rich household to survive, albeit at minimal levels of water consumption. The results of the welfare analysis also provide insight into meaningfully combining the typical equity-efficiency trade-offs and the universality principle of human rights.

It is immediately obvious that fulfilling the right can only go as far as the physical and financial resources allow. The fiscal policy may be impossible to implement or, in other cases, unnecessary to implement. The need for direct government fulfillment is mitigated if instead the government focuses on alternative policies such as spurring income growth, increasing conservation efforts, or lowering the price of the backstop technology. Finally, depending on prices, the results imply the need for different levels of income inequality to fulfill the human right to water. For the effectiveness of the human rights fiscal policy, for example, if the poor household cannot afford water then the rich household needs to be rich enough to afford the subsidy and, at least, its own minimum water requirement. Conversely, if the poor household can always afford water, then the distribution of income is unimportant except for the possibility of changes in prices or incomes engendering water affordability problems for the poor.

To understand the human right to water and its vast implications, the remainder of the paper constructs a framework for analyzing the obstacles the right faces in a world of limited financial and physical resources. First the human right to water is defined within the context of government obligations to respect, protect, and fulfill the right. Then the notation and theory used to capture the general physical and economic environment is introduced. Next the basic human rights and economic framework is developed and discussed in detail. This is followed by a section on social welfare analysis. The paper concludes with a summary of the findings interlaced with a discussion on the nature of interdisciplinary economics and human rights research.

2 The Human Right to Water and Government Obligations

General Comment 15 outlines individual and group consumption concerns, as well as government obligations to respect, protect, and fulfill the human right to water. The individual and group consumption concerns include availability, quality, and accessibility. Availability is defined as a sufficient and continuous supply of water that can be used for "drinking, personal sanitation, laundry, food preparation, and personal and household hygiene (General Comment 15, page 5)." Drinking includes the direct consumption of beverages as well as indirectly through foodstuffs. Quality water is "free from micro-organisms, chemical substances, and radiological hazards that constitute a threat to a person's health (page 5)." The water supply must also be of an "acceptable colour, odour, and taste for each personal and domestic use (page 5)." Accessibility is split into physical and economic accessibility, non-discrimination, and information accessibility. A water source that is within safe physical reach and free from threats to physical security is considered physically accessible. Economic accessibility requires that water must be affordable for all, and excluding certain groups of the population from water and water facilities violates non-discrimination. Information accessibility is framed as the right to "seek, receive, and impart information concerning water issues (page 6)." We consider only availability and economic accessibility, by assuming that : (1) water is of a uniform quality suitable for at least drinking; (2) there is unimpeded physical accessibility for all; (3) there is no discrimination; and (4) information is fully available and costless to obtain.[9] These assumptions are not innocuous; many of the world's water related problems are associated with physical inaccessibility, discrimination, asymmetric information, and poor water quality.

Defined in terms of interference, the obligations of conduct (i.e., respect, protect, and fulfill) impose positive and negative duties on the government. To respect indicates that the government must not interfere with enjoyment of the right to water (General Comment 15, page 9). Protection requires that the government prevents third party interference of enjoyment of the right to water (pages 9-10). To fulfill suggests that governments must adopt the necessary measures to direct toward the full realization of the right (pages 10-11). Fulfillment is further broken down into facilitate, promote, and provide. Facilitation obligates the state to take positive measures for individuals to enjoy the right, while promotion is akin to educating water users about hygiene, protecting water sources, and minimizing water waste. Provision obligates the government to fulfill the right when individuals or a group are unable to do so for reasons beyond their control. The provision aspect is the central focus of this paper as the government is implicitly assumed to be able to fully respect the right.[10]

3 Physical Environment

There are two types of water: groundwater and a backstop supply. Without groundwater recharge, the stock of groundwater, X_t, evolves according to the following law of motion:

$$X_{t+1} = X_t - A_t, \tag{1}$$

where A_t is the total amount of groundwater extracted and consumed by both households in period t. Denote the poor household by $i = 1$ and the rich household by $i = 2$, and let the total number of households be S, then $A_t = \sum_{i=1}^{S} a_{it}$. The price of groundwater, $C(X_t)$, is a decreasing function of the stock left in the ground, X_t: $\frac{\partial C(X_t)}{\partial X_t} < 0$.

Following Nordhaus et al. (1973), there is an infinite supply of backstop water, W, available at a fixed marginal cost of P_B where initially (i.e., at $t = 0$) $P_B \gg C(X_t)$. As the stock of groundwater is depleted, the price of groundwater approaches that of the backstop, eventually equaling it. Denote by $B \ll W \; \forall t$ the total amount of backstop water consumed by S. If the stock of groundwater is a geologic aquifer then two relevant backstop technologies are bottled water and desalinized water. For bottled water, P_B is considerably larger than $C(X_t)$ to account for bottling and shipping costs, water purification, and other related costs. For desalinized water, P_B is considerably larger than $C(X_t)$ in order to capture the relevant cost of provision, disposal of the salt brine, and infrastructure costs. Provision of desalinized water could be prohibitively costly for various institutional, physical, and economic reasons, especially for landlocked countries. The same is true for bottled water. In a crude way, a higher backstop price captures these additional costs that are not explicitly accounted for in the analysis. Nonetheless, the relative scarcity of groundwater and the impact this has on

$C(X_t)$ could eventually make P_B seem like an affordable option.

3.1 The Effective Price of Water

Given the two types of water, the price can be written as:

$$P_{Q_t} = \delta C(X_t) + (1-\delta)P_B, \tag{2}$$

where δ is an indicator variable that behaves as follows:

$$\delta = \begin{cases} 1 & \text{if } C(X_t) < P_B \\ 0 & \text{if } C(X_t) = P_B. \end{cases} \tag{3}$$

As groundwater and backstop water are assumed to be of the same quality, the total amount of water consumed in t, Q_t, is determined as follows:

$$Q_t = \begin{cases} A_t & \text{if } C(X_t) < P_B \\ B & \text{if } C(X_t) = P_B, \end{cases} \tag{4}$$

where $B = \sum_{i=1}^{S} b_i$. Under this quality assumption, households view both types of water as perfect substitutes and will opt for the cheaper of the two. Assuming different qualities of water would require different pricing structures for each quality as well as a different demand curve for each.

3.2 Government Owned Water Supply

Similar to the substitutability function modeled by Roumasset and Wada (2010), the total amount of water consumed is written as $Q_t = A_t + B$. To keep the analysis simple, both types of water are supplied by the government at marginal cost according to the following zero profit condition:

$$P_{Q_t}Q_t = C(X_t)A_t + P_B B. \tag{5}$$

Dinar et. al. (1997) note the advantages and disadvantages of implementing a marginal cost pricing mechanism, or what they call MCP. First, MCP offers a theoretically efficient way to impose an economically and socially optimal allocation of water resources. Furthermore, the relative scarcity of water is reflected in a rising marginal cost, as is the case for $C(X_t)$. Third, a MCP approach can incorporate corrective policies to address consumption and production externalities. Unfortunately, there are many substantive disadvantages as well. For example, marginal cost differs depending on the time period in question. Under MCP, users could experience a jump in the price to account for expanding the water supply when an existing supply runs out. Another disadvantage is that MCP ignores the user cost of water, potentially leading to overuse. Perhaps the most important disadvantage within the context of the human right to water is that a MCP framework directly neglects equity issues. However this analysis addresses that concern with the government fiscal policy directed at water affordability for the relatively poor.

4 Economic Environment

4.1 Households

There are two representative households, of the same size, differing by level of income and denoted by $i \in \{1, 2\} = \{\text{poor, rich}\}$. Each household purchases a composite consumption good c_{it} at a price of P_c (the numéraire), and water, q_{it} at P_{Q_t}. The minimum consumption requirement for water is denoted by γ and is the same $\forall i$. The price at which i can afford to purchase only γ is called $\bar{P}^i_{Q_t}$. Each household is assumed to have the relevant mechanisms to extract groundwater from the government-owned source. Relaxing this assumption would force households to incur additional costs stemming from technological purchases or time lost traveling to/from the source.

4.2 Government Fiscal Policy

The government has a duty to ensure that each household can consume at least γ, with an explicit focus on the poor. To do so, it can impose taxes on the rich and distribute subsidies to the poor that cannot afford γ. Formally, the government faces the following budget constraint in some period t:

$$\xi \times \tau_{it} = \pi_{it}, \tag{6}$$

where ξ is an indicator variable that behaves as follows:

$$\xi = \begin{cases} -1 & \text{if the rich require a subsidy,} \\ 1 & \text{otherwise.} \end{cases} \tag{7}$$

If $\xi = 1$, the tax proceeds in t, τ_{it} are derived from the rich household, and the subsidy payments, π_{it}, are directed to the poor household. If the physical and economic environment are such that the rich household eventually requires a subsidy (i.e., $\xi = -1$), then the source of the tax burden is undefined.

Lump-sum payments to households intended for one use are are often directed to various uses, and this policy could be criticized on these grounds.[11] However, since water is a biological requirement for households, there is an implicit constraint on the use of the subsidy. Households must use it to purchase water or face severe physical health consequences (i.e., death) from not consuming the minimum amount. If the subsidy is directed to households prior to reaching γ, they may in fact use the funds to purchase more of the composite consumption good.

5 Combined Framework

5.1 Households

The rich household is endowed with more income than the poor household, where $M_{2t} > M_{1t}$. Incomes grow at some exogenously given rate $(1+g_i)^t$ and thus, $M_{it}(1+g_i)^t$ is the total endowment of i in t, and $M_{it+1}(1+g_i)^{t+1} > M_{it}(1+g_i)^t$, though $M_{it+1} = M_{it}$. Let $g_i \in [0,1)$ where $g_2 \geq g_1 \; \forall t$. The utility function of household i takes the following form:

$$U^{it} = \begin{cases} V(c_{it}, q_{it}) & \text{if } q_{it} \geq \gamma \\ 0 & \text{if } q_{it} < \gamma (i.e., death). \end{cases} \tag{8}$$

The function, V, exhibits diminishing marginal utility in c and q, and a representative household solves the following problem each period,

$$\max_{c_{it}, q_{it}} U^{it}(c_{it}, q_{it}) \tag{9}$$

$$\text{subject to,}$$

$$M_{it}(1+g_i)^t + \sigma^i_\gamma = P_{Q_t} q_{it} + c_{it}. \tag{10}$$

where σ^i_γ captures the lump sum fiscal policy directed to household i. For $i = 1$, σ^1_γ represents the subsidy payments to the poor, while for $i = 2$, σ^2_γ represents either the tax proceeds from the rich or the subsidy payment required by the rich, depending on the value of ξ in equation 7.

Solving $i's$ utility maximization problem yields the following demand functions:

$$c^*_{it} = \begin{cases} c_{it}(M_{it}(1+g_i)^t, \sigma^i_\gamma, P_{Q_t}), & \text{for } q_{it} > \gamma \\ 0 & \text{for } q_{it} = \gamma \end{cases} \tag{11}$$

$$q^*_{it} = \begin{cases} q_{it}(M_{it}(1+g_i)^t, \sigma^i_\gamma, P_{Q_t}), & \text{for } q_{it} > \gamma \\ \gamma & \text{for } q_{it} = \gamma, \end{cases} \tag{12}$$

where total demand for c_{it} and q_{it} in period t is $c^*_{1t} + c^*_{2t} = c_{St}$ and $q^*_{1t} + q^*_{2t} = Q_t$.

Given the pricing function for water and the trade-off between reaching at least γ and purchasing c, it is likely that i has $c_{it} = 0$ while $q_{it} = \gamma$. This is a problem for the realism of the model as it implies that i is living solely off of water and no longer purchases food, clothing, housing, or other goods and services. Including a minimum consumption requirement over c addresses this problem but causes the water affordability and consumption problem to occur sooner. From a practical and empirical perspective, however, a minimum consumption requirement on non-water goods is an important consideration the government will have to address in its policy directives.

5.2 Graphical Analysis for $g_1 = g_2 = 0$

Without choosing a direct functional form for V, the essence of the problem is captured in a diagrammatic analysis. The baseline case examines static income endowments for both households. This means that the purchasing power of households declines as the price of groundwater rises; households are forced to use increasing portions of their income to purchase water.

The upper panel of Figure 1 represents the utility function of household i as a function of the demand for water. Based on U_{it}, i has a typical utility function for $q_{it} \geq \gamma$ but has $U = 0$ when $q_{it} < \gamma$.[12] The lower panel represents $i's$ demand curve for water, D_i, and is stacked under the utility function to express the relationship between demand, water consumption, and γ.

[Figure 1 About Here]

Figure 2 includes the pricing functions for groundwater and backstop water. The point at which $C(X_t) = D_i$ yields $i's$ equilibrium consumption quantity of groundwater. As households withdraw groundwater, the marginal cost of extraction increases to some $C(X_t)$, possibly even to $\bar{P}^i_{Q_t}$ as in Figure 3, where i can only afford to purchase γ. This could occur at different points in (P, Q) space for an evolving γ.[13] If the price of groundwater rises to $C(X_{t+n})$, as in Figure 4, then $i = 1$ will need a subsidy in the amount of $[C(X_{t+n}) - \bar{P}^1_{Q_t}]\gamma$. Assuming there are sufficient tax proceeds in the economy to support this subsidy, the payment stabilizes at $[P_B - \bar{P}^1_{Q_t}]\gamma$.

[Figures 2, 3, and 4 About Here]

Figure 5 includes the demand for water for the rich household, D_2. Reflecting solely the income difference between the rich and poor households, D_2 is a parallel shifted version of D_1 for $q_{2t} > \gamma$. At P'_B, the rich household will eventually require a subsidy payment as well. However, at P''_B, the ultimate subsidy needs are unclear. The rich might be able to purchase their own water as well as cover some fraction of the subsidy to the poor. It may be however, that the rich have to reduce their own consumption of q or c in order to afford a portion of the subsidy. Whether or not this also forces the rich household into the same situation as the poor household depends on where P_B falls relative to the $\bar{P}^1_{Q_t}$ and $\bar{P}^2_{Q_t}$. What is immediately obvious, however, is that under certain conditions, the ability of the poor household to consume γ is contingent on the income level of the rich. If there is still a poor and rich distinction, and $\bar{P}^1_{Q_t} > P_B$, then the relative income level of the rich is irrelevant for the purposes of the fiscal policy. On the other hand, if $P_B > \bar{P}^1_{Q_t}$, then if $i = 2$ is not sufficiently rich, implementing the fiscal policy will be impossible.

[Figure 5 About Here]

Figure 6 combines the dynamics of the time path of water consumption, including the behavior of the price, for the case when neither household requires a subsidy. Initially, for some price of groundwater, $C(X_0)$, households withdraw water $a_{1,0} + a_{2,0}$. As $C(X_t)$ rises, eventually reaching P_B, households switch to the backstop supply and consume $b_1 + b_2$. The bottom panel represents the time path of Q_t as derived from the individual paths in the middle panel.

[Figure 6 About Here]

In the absence of a government policy, the increasing price of groundwater may eventually force the poor household into water poverty or worse. Though the decision to move is absent from this model, the rich could decide to move in reality. If one type of household exits the economy, either voluntarily or otherwise, the price of groundwater would rise at a lower rate, thereby prolonging the life of the source.

5.3 Total Demand and the Price of Water

Using the total demand for water, the implications for P_{Q_t} are examined by rewriting the law of motion for groundwater as:

$$X_{t+1} = X_t - A_t^*, \tag{13}$$

where $A_t^* = [a_{1t}^* + a_{2t}^*]$. As this is a model without uncertainty, each household knows when $C(X_t)$ will reach P_B. In this sense, the households are prepared for the behavior of the price of water and consume accordingly. Depending on the rate of change of the price, the timing of the fiscal policy, as well as the dollar amount, could vary considerably.

The government's fiscal policy can be summarized in the following way. If $P_B \leq \bar{P}_{Q_t}^1$, there is never a need for a subsidy to either household. Households rely on the groundwater source until $C(X_t) = P_B$, at which point they use the backstop supply. If $\bar{P}_{Q_t}^2 = P_B > \bar{P}_{Q_t}^1$, the poor will eventually require a subsidy. However, the rich might be able to only provide for themselves while the poor are left without water. Lastly, if $P_B > \bar{P}_{Q_t}^2 > \bar{P}_{Q_t}^1$, the rich will eventually require a subsidy as well. The funds for the subsidy to the poor could initially be derived from the rich. Then, however, the rich will require a subsidy payment too, and the source of the tax burden, as well as the fate of all households, are uncertain.

5.4 Analysis for $1 > g_2 \geq g_1 > 0$

The preceding analysis assumes household incomes do not grow and as the price of groundwater rises, the household has to allocate its endowment across an increasingly expensive good and a fixed price good. Exogenously growing endowments mitigate the need for a fiscal policy to meet the minimum consumption requirement for i. Let household i now have an endowment of $M_{it}(1+g_i)^t$ for $g_i \in (0,1)$ and $g_2 \geq g_1$. Exogenously growing incomes represent growth in nominal income levels and are a simplification of an actual labor/leisure decision. Whether or not real income grows depends on the purchasing power of each household relative to $C(X_t)$ and P_B.

Assuming water and the composite consumption good are normal goods, as income grows, so too does demand for each good. Following Borissov and Surkov (2010), the rate of groundwater extraction is defined as $\nu_t = \frac{A_t}{X_t}$. The optimal extraction rate at which $A_t = a^*_{1t} + a^*_{2t}$ is defined as $\nu^*_t = \frac{A^*_t}{X_t}$. If the income of each household is growing at a rate faster than the price of groundwater rises to meet that of the backstop supply, it is possible that there is no need for a subsidy to any income group. If income is growing at a lesser rate, the situation would be the same as in the basic framework. This relationship is formalized by considering the time period, $T \in [0, 1, 2, \ldots, T-2, T-1, T, T+1, T+2, \ldots]$, at which $C(X_T) = P_B$:

$$C(X_T) = C(X_{T-1} - A^*_{T-1}) = P_B, \tag{14}$$

where the comparison between q^*_{1T} and γ and determines T.

As income grows the need for the subsidy is diminished and possibly even eliminated. Similar to the static income case, if one income group voluntarily or involuntarily leaves the economy, there would be a decline in the rate at which the price of groundwater rises. Depending on the size of the group that exits, the effect on the price could be significant enough to halt the need for a subsidy, especially if incomes are growing. If the rich voluntarily leave, the outcome could be favorable for the poor, both in terms of water affordability and obtaining γ independently, but potentially unfavorable in other respects.

5.5 Formalized Tax and Subsidy Policy

The government faces a balanced budget constraint at the point in time when it has to provide a subsidy to those households which are unable to afford γ. For the case where only the poor household requires a subsidy, the payment to $i = 1$ is the following,

$$\pi_{1t} = \gamma[C(X_{t+n}) - \bar{P}^1_{Q_t}], \tag{15}$$

with stability at $\gamma[P_B - \bar{P}^1_{Q_t}]$. Since there is only one representative household of each income type, equation 15 also defines the tax burden on the rich household. The government's budget constraint is satisfied when the tax burden on the rich household equals the subsidy payment to the poor household.

For the case where the poor and rich household both require a subsidy, the amount required is,

$$\gamma[C(X_{t+n}) - \bar{P}^1_{Q_t}] + \gamma[C(X_{t+m}) - \bar{P}^2_{Q_t}], \tag{16}$$

where $C(X_{t+m}) > C(X_{t+n})$ and $\bar{P}^2_{Q_t} > \bar{P}^1_{Q_t}$, and with stability at $\gamma[2P_B - \bar{P}^1_{Q_t} - \bar{P}^2_{Q_t}]$. In this case, the government's budget constraint is considerably more complicated as the government has to provide the poor household with a subsidy from some period t and also provide the rich household with a subsidy from some later time period. However, without an additional source of tax proceeds, there are *no* subsidy payments if the rich household also requires them. Though the government could perhaps use monetary policy or deficit spending to create funds for the fiscal policy, the constraints of the real economy render these options infeasible. The government may therefore never be able to independently provide a subsidy to either type of household, or may run out of funds to continue providing subsidies. In the latter case, there are a few options that could alleviate the potential problems associated with such water poverty. First, the government could enact policies to (1) spur income growth;

(2) improve the technological feasibility of the backstop technology, thereby reducing its price; or (3) encourage conservation and groundwater recharge. The effects of these policies could perhaps be realized without government intervention, however. Second, the inclusion of firms in the analysis might offer an additional resource base for tax proceeds, especially firms that use water. Third, the international community could intervene to provide funds and/or water resources (i.e., extraterritorial obligations). Fourth, the government could borrow funds, though without a significant tax base to eventually pay the funds back, it runs the risk of defaulting on its sovereign debt. Also, even if the government could provide a subsidy to those in need, said households may simply be consuming the minimal amount of water. Having additional financial resources to ensure a minimum water requirement can certainly help fulfill the right, but such an outcome may be rather dismal, where the minimum requirement evolves into maximum provision (Chapman, 2007).

It is worth noting that the aforementioned fiscal policy is not the only policy option. It is possible that the government could impose a different pricing or tax structure to penalize consumption beyond γ, while continuing to subsidize consumption to reach γ. For example, a rising block-rate water pricing system or a progressive tax on water consumption. This would have the likely effect of prolonging the life of the groundwater source and building the financial resource base for an eventual subsidy. For the case where households never require a subsidy, the government could simply redistribute the funds or use them to subsidize P_B. We are sensitive to the fact, however, that any fiscal policy will have unintended secondary and tertiary consequences that need to be further explored.

6 Welfare Comparisons

From a human rights perspective, the government is obligated to respect, protect, and fulfill the right to water in the event that any one household cannot do so independently. Furthermore, the universality principle of human rights holds that all humans are entitled to at least a minimum amount of water for domestic use. From an economics perspective, government obligations are vague and difficult to model. The universality principle is hard to incorporate into economic models because it seems to, a priori, reject efficiency criteria for equity concerns. Incorporating human rights aspects into economic models requires seriously rethinking typical equity-efficiency tradeoffs. Conversely, incorporating economic principles into human rights scholarship requires a deeper consideration of the scale, scope, and opportunity costs of the resources required to meet government obligations. Perhaps the key to fusing economic policy with human rights standards is finding a meaningful way to incorporate the universality principle of human rights. This section provides what we think is a first step in this direction.

Economists are often concerned with comparing total social welfare under different policy regimes. If one policy offers higher total social welfare than another, then this is the prescribed policy. In this context, we have many possible welfare outcomes, including those where the poor household no longer exists in the economy. Even if this were welfare maximizing from an economics perspective, it would be an egregious human rights violation.

Without functional forms, welfare comparisons are difficult, though we can define the planner's problem quite simply. From an economics perspective, the problem is to maximize the sum of utility from the poor and rich households, subject to: (1) the income constraints of both households as defined by equation 10; and (2) the law of motion for groundwater defined by equation 1. Since there is an infinite amount of the backstop supply, it is unnecessary to control for this constraint. To define the human rights standard, we add the following household survival constraints: $q_{it} \geq \gamma$ for $i = 1, 2$.

For the optimal consumption levels defined in equations 11 and 12, define unweighted welfare in t as,

$$W_t = U^{1t}(c_{1t}^*, q_{1t}^*) + U^{2t}(c_{2t}^*, q_{2t}^*), \tag{17}$$

which is bounded below by zero and above by $V(c_{1t}^*, q_{1t}^*) + V(c_{2t}^*, q_{2t}^*)$. We define the minimum human rights standard as:

$$W_t^{\gamma} = V(0,\gamma) + V(0,\gamma), \tag{18}$$

which denotes the welfare levels each household receives when $q_{it} = \gamma$.

To simplify welfare comparisons, we reduce the model to a two-period problem with the following assumptions: (1) income endowments are fixed in both periods; (2) $g_1 = g_2 = 0$ $\forall t$; (3) $C(X_t) < P_B$; (4) $C(X_{t+1}) = P_B$; and (5) X_0 is fixed. Thus the parameter that drives optimal consumption levels, and therefore individual utility and total welfare, is the placement of P_B relative to $C(X_t)$, $\bar{P}^1_{Q_t}$, and $\bar{P}^2_{Q_t}$. We define total welfare for both time periods as:

$$\mathbf{W} = \sum_{t=1}^{2} W_t = U^{1t} + U^{1t+1} + U^{2t} + U^{2t+1}. \tag{19}$$

Dropping the $*$ notation from the optimal consumption demands of c^* and q^*, Tables 1-5 represent the variety of outcomes for different water pricing relationships. Table 1 represents the results from assuming perfect income equality. For example, total welfare in Case 1 is equal to zero. In Case 2, $\mathbf{W} = V(c_{1t}, a_{1t}) + V(c_{1t+1}, b_1) + V(c_{2t}, a_{2t}) + V(c_{2t+1}, b_2)$. With perfect income equality, there is no possibility of a subsidy to either household. Table 2 yields identical welfare results, though there is now a distinction between the poor and rich household through income levels. Subsidies are possible, but unnecessary because in $t+1$ the poor household can afford to purchase exactly γ, and will thus obtain $V(0,\gamma)$ in utility.

[Tables 1 and 2 About Here]

In Table 3, given that $P_B > \bar{P}^2_{Q_t}$, the rich household can possibly afford to subsidize the water consumption of the poor household in t but not in $t+1$. For example, in Subcases C1 and C2, where total welfare is higher in C1 because $V(c_{2t}, a_{2t}) > V(0,\gamma)$ for the rich household. In C1, the rich household has enough income leftover to purchase more than the minimum amount of water, which is simply a result of the nature of the fiscal policy. Subcase C3 is interesting because it captures three scenarios. First, including the possibility of a government fiscal policy, the rich household does not have enough income to subsidize the poor and still reach γ. In the second scenario, there is no fiscal policy in place to subsidize the poor household, hence the poor household dies and the rich household can purchase c and $q > \gamma$. In the third case, regardless of a fiscal policy, the welfare maximizing outcome is simply to allow the poor household to die. In other words, C3 captures the failure of the human rights fiscal policy to subsidize the poor household and represents the welfare maximizing outcomes (in this subcase) from an economics perspective. The interesting welfare comparison is thus between C2 and C3, where C2 represents the human rights standard in t. It is possible that C3 represents the welfare maximizing outcome, even if the rich household had enough income to subsidize the poor household. If this were the case, then the question remains as to which total welfare level is higher, that of C2 or C3? Income permitting, W_t^γ would be the preferred outcome for human rights advocates based merely on human dignity, versus allowing the poor household to die in t, even if $W_t^\gamma < \mathbf{W} = V(c_{2t}, a_{2t})$.

[Table 3 About Here]

For a different pricing relationship, as in Table 4, we can discuss similar outcomes. For example, comparing Subcases C2 and C3 yields identical tradeoffs, where the distinction between welfare maximizing outcomes from an economics perspective versus that which human rights advocates would support is important. Table 5 includes considerably more subcases when $\bar{P}^1_{Q_t} < P_B < \bar{P}^2_{Q_t}$. Subcases C4 and C5 represent the difference between welfare equality across households $\forall t$ versus complete welfare inequality, where the poor household dies and the rich household thrives. Again, we have the possibility that the latter case is in fact welfare maximizing though an irreparable human rights violation against the poor household.

[Tables 4 and 5 About Here]

From a human rights perspective, the minimally preferred outcome is any scenario where both households live and obtain at least W_t^γ. Human rights advocates would likely agree with different welfare levels across households within each time period, so long as the poor household at least lives, to say nothing of thriving. Excluding a normative analysis, the typical economic analysis would simply seek the welfare maximizing outcome across any scenario, irrespective of a human rights fiscal policy. With or without a fiscal policy in place, the goal is simply to maximize total welfare. If this occurs with a dead poor household, then we can easily explain why economists are called dismal scientists. Without functional forms, it is difficult to continue speculating on possible outcomes, especially when the total welfare function could be developed using the Rawlsian (1971) *maximin* principle. This functional form maximizes the utility of the least well-off generation or, as in this case, the least well-off household within a generation. The resulting outcome typically equalizes the intergenerational utility of each household, which could be ideal unless the utility of each household were zero (i.e., both households were dead).

7 Conclusion

To better understand the implications of the human right to water, this paper directly integrates human right standards into an economic model of a nonrenewable resource with a backstop technology. Demonstrating the various layers of difficulty involved in fulfilling the human right to water, the results illustrate that fulfillment is very challenging, perhaps even impossible. Furthermore, the welfare analysis demonstrates the difficulty of incorporating the universality principle of human rights into traditional economic analysis. Though we defined a human rights standard, we showed cases where it may not be welfare maximizing to ensure this standard from a traditional economics perspective. This suggests the need for rethinking traditional economic analysis, or perhaps incorporating additional layers of realism.

Under ideal conditions, where all households can afford to purchase at least γ, the government may never have to implement its human rights fiscal policy. This outcome is clearly juxtaposed against the myriad water-related poverty, conflict, and accessibility issues rampant in developed and developing countries. Perhaps some of this could be captured with a more robust modeling framework that includes uncertainty over the groundwater source or timing of the backstop technology, for example. Nonetheless, the results indicate that there may be other policy options to ensure households can afford water, including a relatively high, stable income, sufficient water recharge or conservation efforts, or technological improvements that reduce the price of water. There is much to be done however, both from a modeling and practical perspective.

This analysis also demonstrates that implementing an enforceable human right to water would not only be physically and economically difficult, but doing so may not even mitigate, let alone eliminate, many of the issues surrounding access to and consumption of a certain minimal amount of water. What is clear, however, is that any theoretical or empirical model of the human right to water must consider the underlying supply of water and its associated extraction and user costs. If the resource runs out, there is necessarily none left for future generations, and without a relevant substitute, there will be nothing left for present generations either. Both scenarios have serious human rights implications and beg the question of whether or not humans can have a right to a natural resource that is, or may be geographically or temporally, limited in supply. Perhaps instead, the human right applies to the desalinization technology or both the saltwater and the technology.

This issue of tangible contingency cannot be ignored when the human right relies directly on the provision of some natural or physical resource. One cannot literally touch the underlying provisions of the right to be free of genocide, the right to vote, or the right to work, but one can drink water, bathe in it, and get sick from it. Certainly financial constraints underly the implementation and fulfillment of all human rights, but not all human rights have such physical or natural constraints.

Notes

[1]See the Pacific Institute Water Conflict Chronology Timeline.

[2]See the United Nations Water Statistics website (accessed May, 2011) and the United Nations General Assembly Document A.64/L.63/Rev.1.

[3]See General Assembly document: A/64L.63/Rev.1.

[4]The human right to water is defined as an environmental human right (Hiskes, 2009).

[5]Had Gleick included the amount of water required to meet the daily food needs of a person, the minimum increases by 713 gallons to roughly 726 gallons, a nontrivial increase with serious implications for practically defining the minimum consumption requirement.

[6]See Minkler (2009) for a discussion of these two ways to instantiate economic rights.

[7]Alternatively, a more robust approach would be to implement a dynamic general equilibrium problem, perhaps incorporating overlapping generations, using the maximin utility framework in the spirit of (Solow, 1974), Dasgupta and Heal (1974), Hartwick (1977), Hartwick (1978), Solow (1986), and d'Autume and Schubert (2008), among others.

[8]Since the analysis does not specify the underlying geographical location of the water scarcity problem, fulfilling a human right to water for poor and rich households living in a desert is a possibility but would likely be a contestable use of resources.

[9]For a broader definition of discrimination, the fiscal policy could lead to income discrimination.

[10]Protection is not as easy to assume away. For water conflicts, the notion of interference is clear. However, when people are consuming water from the same source, the nature of interference is unclear and the situation resembles the tragedy of the commons or depletion of a common pool resource (Hardin, 1968; Ostrom, 1990). Solving the common good or public good problem of overconsumption is not part of this paper, although doing so could have implications for the fulfillment of the human right to water.

[11]For example, the intended purpose of the 2001 and 2008 Bush tax rebates was to stimulate

household spending to boost the economy. Respectively, however, Shapiro and Slemrod (2001, 2009) found that a majority of households in fact saved the rebate or used it to pay off debt.

[12]If γ were broken up into the categories, a household might be able to survive for a longer period of time by giving up successively less important categories to obtain at least drinking water.

[13]It is possible in an overlapping generations framework to consider an evolving minimum consumption requirement if future generations of humans require differing amounts of water to survive.

Table 1: Identical Incomes

Time Period	Utility Poor	Rich	Poor get a subsidy?
Case 1: $P_B > C(X_t) > \bar{P}_{Q_t}$			
t	0	0	N/A
t+1	0	0	N/A
Case 2: $\bar{P}_{Q_t} > P_B$			
t	$V(c_{1t}, a_{1t})$	$V(c_{2t}, a_{2t})$	N/A
t+1	$V(c_{1t+1}, b_1)$	$V(c_{2t+1}, b_2)$	N/A
Case 3: $P_B = \bar{P}_{Q_t}$			
t	$V(c_{1t}, a_{1t})$	$V(c_{2t}, a_{2t})$	N/A
t+1	$V(0, \gamma)$	$V(0, \gamma)$	N/A

Table 2: Welfare Analysis (2 of 4)

Time Period	Utility: Poor	Utility: Rich	Poor get a subsidy?
Case 1: $P_B > C(X_t) > \bar{P}^2_{Q_t}$			
t	0	0	N/A
t+1	0	0	N/A
Case 2: $\bar{P}^1_{Q_t} > P_B$			
t	$V(c_{1t}, a_{1t})$	$V(c_{2t}, a_{2t})$	N
t+1	$V(c_{1t+1}, b_1)$	$V(c_{2t+1}, b_2)$	N
Case 3: $P_B = \bar{P}^1_{Q_t}$			
t	$V(c_{1t}, a_{1t})$	$V(c_{2t}, a_{2t})$	N
t+1	$V(0, \gamma)$	$V(c_{2t+1}, b_2)$	N

Table 3: Welfare Analysis (2 of 4)

Time Period	Utility Poor	Utility Rich	Poor get a subsidy?
Case 4: $P_B > \bar{P}^2_{Q_t}$			
Subcase A: $C(X_t) < \bar{P}^1_{Q_t} < \bar{P}^2_{Q_t}$			
t	$V(c_{1t}, a_{1t})$	$V(c_{2t}, a_{2t})$	N
t+1	0	0	N/A
Subcase B: $C(X_t) = \bar{P}^1_{Q_t} < \bar{P}^2_{Q_t}$			
t	$V(0, \gamma)$	$V(c_{2t}, a_{2t})$	N
t+1	0	0	N/A
Subcase C1: $\bar{P}^1_{Q_t} < C(X_t) < \bar{P}^2_{Q_t}$			
t	$V(0, \gamma)$	$V(c_{2t}, a_{2t})$	Y
t+1	0	0	N/A
Subcase C2: $\bar{P}^1_{Q_t} < C(X_t) < \bar{P}^2_{Q_t}$			
t	$V(0, \gamma)$	$V(0, \gamma)$	Y
t+1	0	0	N/A
Subcase C3: $\bar{P}^1_{Q_t} < C(X_t) < \bar{P}^2_{Q_t}$			
t	0	$V(c_{2t}, a_{2t})$	N/A
t+1	0	0	N/A

Table 4: Welfare Analysis (3 of 4)

Time Period	Utility Poor	Utility Rich	Poor get a subsidy?
Case 5: $P_B = \bar{P}^2_{Q_t}$			
Subcase A: $C(X_t) < \bar{P}^1_{Q_t} < \bar{P}^2_{Q_t}$			
t	$V(c_{1t}, a_{1t})$	$V(c_{2t}, a_{2t})$	N
t+1	0	$V(0, \gamma)$	N/A
Subcase B: $C(X_t) = \bar{P}^1_{Q_t} < \bar{P}^2_{Q_t}$			
t	$V(0, \gamma)$	$V(c_{2t}, a_{2t})$	N
t+1	0	$V(0, \gamma)$	N/A
Subcase C1: $\bar{P}^1_{Q_t} < C(X_t) < \bar{P}^2_{Q_t}$			
t	$V(0, \gamma)$	$V(c_{2t}, a_{2t})$	Y
t+1	0	$V(0, \gamma)$	N/A
Subcase C2: $\bar{P}^1_{Q_t} < C(X_t) < \bar{P}^2_{Q_t}$			
t	$V(0, \gamma)$	$V(0, \gamma)$	Y
t+1	0	$V(0, \gamma)$	N/A
Subcase C3: $\bar{P}^1_{Q_t} < C(X_t) < \bar{P}^2_{Q_t}$			
t	0	$V(c_{2t}, a_{2t})$	N/A
t+1	0	$V(0, \gamma)$	N/A

Table 5: Welfare Analysis (4 of 4)

Time Period	Utility Poor	Utility Rich	Poor get a subsidy?
Case 6: $\bar{P}^1_{Q_t} < P_B < \bar{P}^2_{Q_t}$			
Subcase A1: $C(X_t) = \bar{P}^1_{Q_t}$			
t	$V(0,\gamma)$	$V(c_{2t}, a_{2t})$	N
t+1	$V(0,\gamma)$	$V(c_{2t+1}, b_2)$	Y
Subcase A2: $C(X_t) = \bar{P}^1_{Q_t}$			
t	$V(0,\gamma)$	$V(c_{2t}, a_{2t})$	N
t+1	$V(0,\gamma)$	$V(0,\gamma)$	Y
Subcase A3: $C(X_t) = \bar{P}^1_{Q_t}$			
t	$V(0,\gamma)$	$V(c_{2t}, a_{2t})$	N
t+1	0	$V(c_{2t+1}, b_2)$	N/A
Subcase B1: $C(X_t) < \bar{P}^1_{Q_t}$			
t	$V(c_{1t}, a_{1t})$	$V(c_{2t}, a_{2t})$	N
t+1	$V(0,\gamma)$	$V(c_{2t+1}, b_2)$	Y
Subcase B2: $C(X_t) < \bar{P}^1_{Q_t}$			
t	$V(c_{1t}, a_{1t})$	$V(c_{2t}, a_{2t})$	N
t+1	$V(0,\gamma)$	$V(0,\gamma)$	Y
Subcase B3: $C(X_t) < \bar{P}^1_{Q_t}$			
t	$V(c_{1t}, a_{1t})$	$V(c_{2t}, a_{2t})$	N
t+1	0	$V(c_{2t+1}, b_2)$	N/A
Subcase C1: $C(X_t) > \bar{P}^1_{Q_t}$			
t	$V(0,\gamma)$	$V(c_{2t}, a_{2t})$	Y
t+1	$V(0,\gamma)$	$V(c_{2t+1}, b_2)$	Y
Subcase C2: $C(X_t) > \bar{P}^1_{Q_t}$			
t	$V(0,\gamma)$	$V(c_{2t}, a_{2t})$	Y
t+1	$V(0,\gamma)$	$V(0,\gamma)$	Y
Subcase C3: $C(X_t) > \bar{P}^1_{Q_t}$			
t	$V(0,\gamma)$	$V(c_{2t}, a_{2t})$	Y
t+1	0	$V(c_{2t+1}, b_2)$	N/A
Subcase C4: $C(X_t) > \bar{P}^1_{Q_t}$			
t	$V(0,\gamma)$	$V(0,\gamma)$	Y
t+1	$V(0,\gamma)$	$V(0,\gamma)$	Y
Subcase C5: $C(X_t) > \bar{P}^1_{Q_t}$			
t	0	$V(c_{2t}, a_{2t})$	N/A
t+1	0	$V(c_{2t+1}, b_2)$	N/A

8 Figures

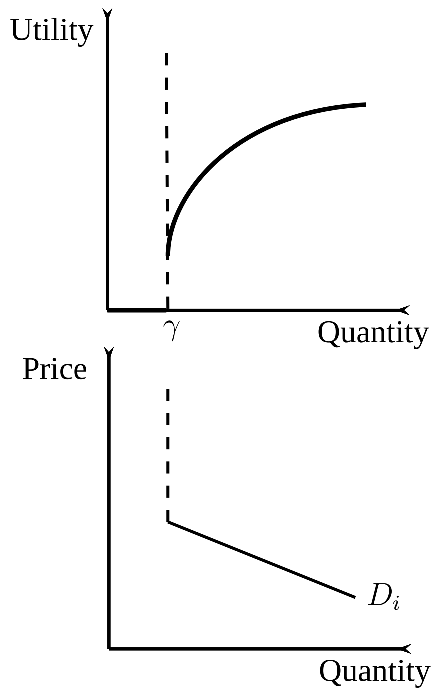

Figure 1: Utility and the Demand for Water

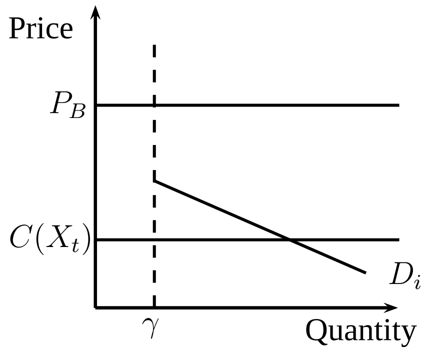

Figure 2: Water Demand with Groundwater and Backstop Prices

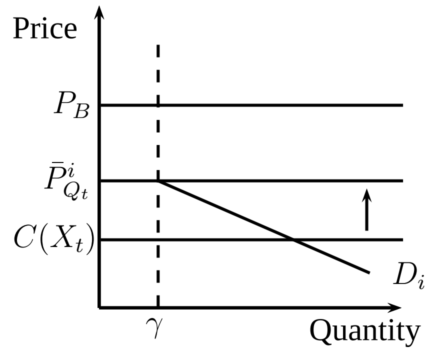

Figure 3: Household i Can Only Afford γ

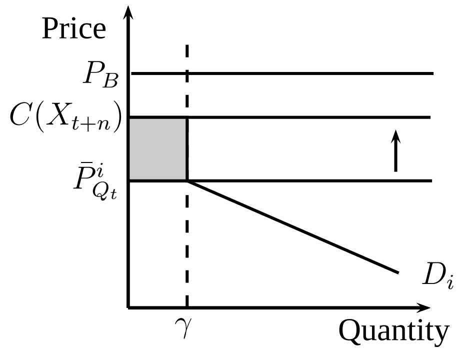

Figure 4: Subsidy Requirement as $C(X_t)$ Approaches P_B

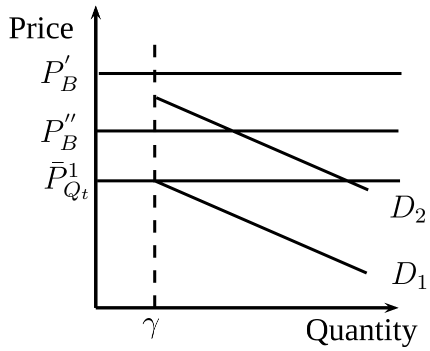

Figure 5: Rich and Poor Demand for Water

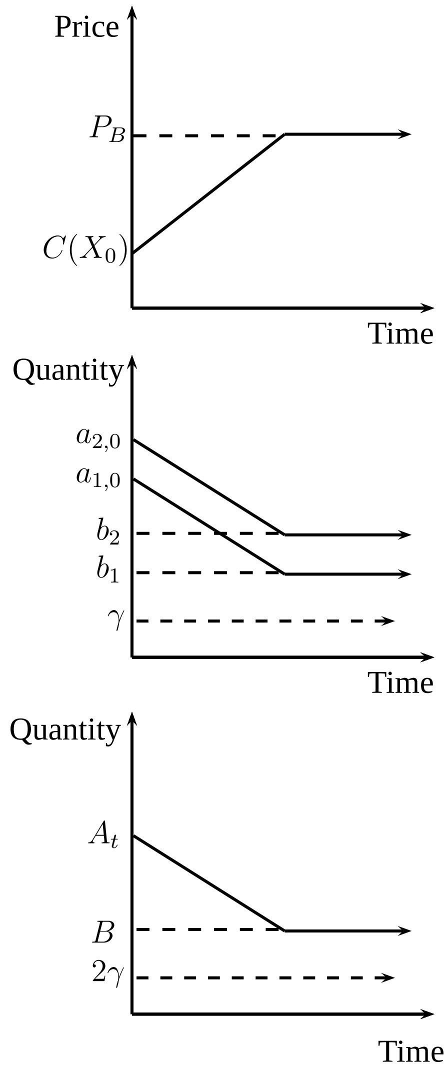

Figure 6: Dynamics of the Time Path of Water Consumption

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