Natural Resources
FORUM

Natural Resources Forum 26 (2002) 89–100

Tackling the issue of rural–urban water transfers in the Ta'iz region, Yemen

Khalid Riaz

Abstract

The Ta'iz region of Yemen is facing serious water problems. Total water use has become unsustainable. While agriculture places a heavy demand on the region's water resources, supplies for the fast growing city and the industrial sector are severely rationed despite their much higher willingness-to-pay for water relative to the returns on most agricultural uses. The article considers several decentralized management options for enhancing sustainability and improving intersectoral water allocation. These include, taxing groundwater extractions, taxing inputs used in pumping groundwater, and implementing a tradable water rights regime. The first two options could lead to resource conservation but are politically difficult to implement and may not necessarily result in better intersectoral water allocation. The tradable water rights regime has potential for achieving the twin objectives of resource conservation and improved intersectoral resource allocation. If farmers' de facto water rights were legitimized, this option would be more acceptable to them. However, the following additional conditions need to be met for making the option viable: (a) a set-aside allocation is made for lifeline supplies for the poor; (b) the water law provides for separation of water rights from land rights; and (c) community organizations are involved as co-managers of the region's water resources.

Keywords: Water allocation; Water transfers; Tradable water rights; Water markets; Groundwater; Decentralized water resources management; Ta'iz; Yemen

1. Water situation in Yemen

Yemen is one of the few countries in the world that have an 'extremely severe water scarcity problem' (Cestti, 1989).[1] The estimated per capita availability of renewable water resources was only about 133m^3 in 1994 and could be even lower now. This does not compare favorably with the average availability of 1,250 m^3 per annum in the Middle East and North Africa Region and 7,500 m^3 per annum worldwide (World Bank, 1997). Water scarcity is more acute in the western part of the country where 90% of the population is concentrated. In these parts, wherever major cities are located in catchments with limited local water resources, the water problem tends to assume crisis proportions. Examples of such water-stressed catchments are the upper Wadi Rasyan and Sana'a Basin that include, respectively, the city of Ta'iz and Sana'a (the capital). It is here that competing water demands from the fast expanding cities and the rural areas, depending heavily on irrigated agriculture, generate social and political conflicts that have remained unresolved.

This article proposes a framework for tackling the rural–urban water-transfer issues in the Ta'iz region. However, the framework has a broader general applicability in Yemen. The next section describes the water problem in the Ta'iz (upper Wadi Rasyan) region. This is followed in section 3 by a diagnostic analysis of the water situation in the area. Section 4 considers a range of institutional options available for dealing with the problems of unsustainable groundwater use and intersectoral water allocation. Section 5 proposes a framework based on the notion of tradable water rights for resolving the contentious issue of rural–urban water transfer facing the area. The final section deals with some practical issues in implementing the framework.

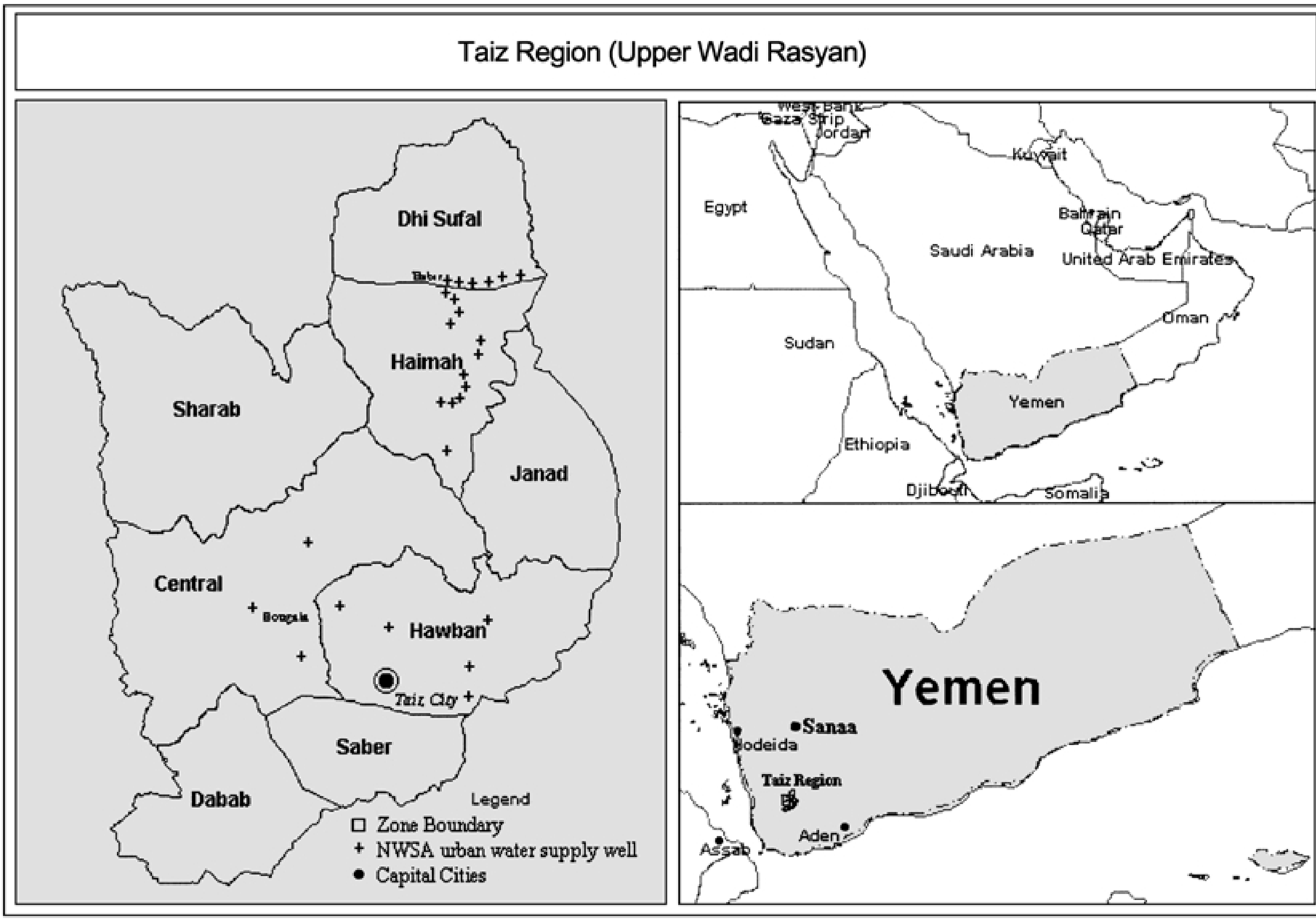
2. The Ta'iz water crisis

According to the 1994 population census, the total population of the Ta'iz region[2] was 650,000, out of which 317,000

The author is Water Resources Economist with the UN Department of Economic and Social Affairs and the National Water Resources Authority (NWRA), Yemen.
All views expressed in this article are solely those of the author and should not be attributed to any organization that he may be associated with.

[1] Cited in Technical Secretariat of High Water Council, 1992.

[2] Taken here to be the upper Wadi Rasyan catchment.



people lived in Ta'iz City. Since the previous census in 1986, the urban population had grown at an alarming 7.9%, while the rate of increase in the rural population was around 3.7% (Taher, 1998). These high rates of population growth have exerted pressure on the limited water resources of the catchment and the situation is expected to become worse in the future unless suitable measures are taken.

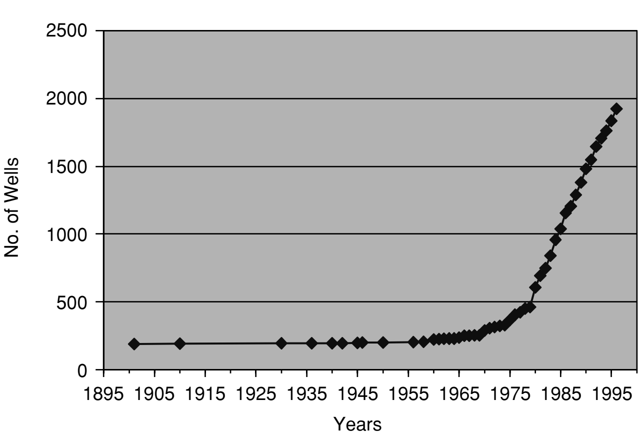


Figure 1. Trends in groundwater development
Source: Well inventory data collected in 1996 by the National Water Resources Authority, Yemen.

The population pressure on water resources is reflected in the very rapid increase in the number of wells established in the area over the last two decades. In the mid-1970s, there were only 180 wells in the catchment but this number had increased to 2,299 by 1996, and included 1993 dug wells and 306 boreholes. Figure 1 clearly shows the boom in groundwater development starting in the early 1980s. Apart from increasing population pressure on water resources and the availability of pump technology for exploiting them, two other factors acted as catalysts. First, increasing remittances from Yemenis working abroad provided the capital needed for financing investments in groundwater wells. Second, government policies aimed at increasing self-sufficiency in agricultural production, including a ban on fruit imports (imposed in 1983), a long-standing ban on importing *qat*,[3]

[3] The leaves of the *qat* plant (*Catha edulis*) are a mild stimulant. *Qat*-chewing is a widespread custom in Yemen. Because of the ban on import of *qat*, a considerable land area and water resources in the country are devoted to its cultivation. According to Riaz (1999a), the share of *qat* in farmed area in Upper Wadi Rasyan was around 12%.

and the subsidizing of pumps and implicit import subsidies on drilling equipment, helped increase the profitability of private investments in groundwater development (Ward, 1998).

During the same period, the city of Ta'iz expanded rapidly as people migrated there from rural areas. Industries located in and around the city undoubtedly attracted people, but the stagnation of agricultural productivity under increasing population pressure on land in the rural areas also contributed significantly to the recent migration, which resulted in increased urban water demand. Although the industries provided employment, they also required water. The water resources of the upper Wadi Rasyan catchment were not sufficient to meet the combined demands of agriculture, industry and domestic uses in Ta'iz City.

Initially, the urban water needs were met from the Hawban-Haugala wells located just outside the city. However, as population increased, so did domestic water demand. Between 1977 and 1982, new wells were developed about 20km northeast of Ta'iz City in Wadi Al-Haima, which is a sub-catchment of Upper Wadi Rasyan (see map). At that time, Wadi Al-Haima was a prime agricultural zone of Ta'iz where significant quantities of groundwater were also being extracted for irrigation. Competition for groundwater between farmers and the urban water utility, the National Water and Sanitation Authority (NWSA), led to depletion of the Al-Haima aquifer.[4] The wells of many farmers went dry in the southern part of Al-Haima, causing shortages of irrigation water and drastic declines in agricultural incomes.[5] This caused deep resentment among the local communities who blamed the city for the depletion of what they considered their water resources.

The city of Ta'iz was also affected. By 1987, the total yield from NWSA's Al-Haima wells, which had been initially around 19,000m^3/day, had declined to 7,000m^3/day (CES, 1997). Even before this time, the rapidly dwindling water supplies from Al-Haima had led NWSA to consider a crash well-drilling programme. Local communities, depending on irrigated agriculture for their livelihood, vehemently opposed this. The authorities retaliated by arresting several notable persons of the area and sending out troops. The dispute was eventually resolved by the direct intervention of the Minister for Oil, who secured a written agreement from the local communities to let the drilling proceed. Six additional wells were drilled in 1987 and 1988. This helped boost the total production from Al-Haima to 13,000m^3/day — about a third less than the original production level.

But even this further provision offered only a temporary lull in the rural–urban conflict over water. In 1992, local farmers disconnected a government water supply well in the Al-Khazaja area and the dispute erupted again. A representative of the President of the Republic had to intervene to resolve the issue and get the well reconnected (World Bank, 1998). The following year, the President invited five local community leaders (*shyukh*) to the capital, Sana'a, and sought their help in developing new wells in the Habir area, a few kilometres upstream of Al-Haima. The community leaders refused to accept the proposals, however, citing strong opposition from the rural people. Nevertheless, negotiations continued and agreement was finally reached in 1996. By the previous summer, 1995, water availability had declined so much that NWSA was supplying water to the city only once every 40 days. Ta'iz City was in the grip of the most serious water crisis in its history (Handley, 1999).

Table 1. Annual groundwater recharge and water use

Type of use /recharge	Volume
A. Natural groundwater recharge	15.4 Mm^3
B. Groundwater use	40.9 Mm^3
Agriculture (irrig. & livestock)	27.2 Mm^3
Rural domestic water use	2.7 Mm^3
Urban domestic water use	6.8 Mm^3
Industrial water use	4.2 Mm^3

Source: Constructed from information in Van der Gun (1999).

Table 1 presents a snapshot of the water balance of the area only one year after this crisis. The table shows total groundwater use in the area, as well as its sectoral breakdown for the year 1996. Although by this time, the urban water scenario had changed to some degree due to stopgap measures adopted in response to the crisis, the water balance does capture the fundamental features of the Ta'iz water situation.[6]

These fundamental features include the following. The water use in the catchment is far in excess of sustainable annual yield. The total current groundwater use represents 265% of annual groundwater recharge. The aquifers are being mined at a rapid rate and quality degradation is a serious problem. Agriculture is the major water-consuming sector, accounting for about 66% of total groundwater use (27 Mm^3). The urban domestic use was about 7 Mm^3, or 17%. The share of industries was about 10%, at 4.2 Mm^3. The ironic aspect of the Ta'iz water problem is that despite acute scarcity, water use in all sectors is inefficient. Irrigation efficiency is low in agriculture, industries do not recycle water and the urban water utility reports very high 'unaccounted for water', largely due to neglected maintenance of the distribution system (NWRA, 2000).

[4] NWSA is responsible for provision of water supply and sanitation services to Yemeni cities.

[5] The National Water Resources Authority (NWRA) notes (1997) that all dug wells in the Al-Haima area were dry due to intensive pumping from boreholes (p. 17). This is not true throughout the entire Al-Haima zone but it is true for the southern part.

[6] The stopgap measures included increasing production from the Hawban-Haugala wells, which had been put out of operation earlier due to contamination from urban cesspits and leaking sewers. The admixing of this water lowered the overall quality of water supplied to the city. Thus, the urban water managers in fact traded water quantity for water quality.

Table 2. Projections for urban population, and water demands of urban domestic and industrial sectors

Year	Ta'iz urban population	Urban domestic water demand (Mm^3)	Industrial water demand (Mm^3)
2000	494,966	8.2	5.0
2005	702,495	12.5	6.0
2010	980,621	18.9	7.3
2015	1,347,351	27.9	9.0
2020	1,823,467	40.7	11.3

Source: NWRA, 2000.

If the present trends persist into the future, the situation would become progressively worse as urban domestic and industrial water demands projected to 2020 would approach 41 Mm^3 and 11 Mm^3, respectively (see Table 2). In the process, the agriculture sector would come under tremendous pressure to release water to other more rapidly growing and more profitable sectors (i.e. urban domestic and industrial sectors). The question is whether this transition, involving intersectoral reallocation of water, would be smooth or accompanied by heightened social tensions and conflict.

3. A closer look at the water crisis

This section argues that the Ta'iz water crisis is largely a consequence of complex interaction between the following fundamental factors.

- Water users do not take into account the external costs their water use decisions impose on others and there are, at present, no regulatory mechanisms for internalizing these costs;[7]
- In the absence of water rights, individuals cannot lay claim in the future on water saved today; and
- The price signals from urban/industrial water markets with high use values for water fail to reach markets for irrigation water. This is really a consequence of the absence of well-defined water rights, as is argued below.

The rest of this section elaborates this thesis.

Under the present water management regime, sectoral water allocation has come to be seen as a 'zero-sum game'[8] by the parties involved. Aquifers are common pool resources and the rule of capture is the dominant strategy in the game. This is what is described in the literature as the 'tragedy of commons' (Hardin, 1968).

Typically in a tragedy of commons situation, the water users tend to extract water until their private marginal benefit equals their private marginal cost. The private marginal costs are just the pumping costs, which are quite low in the Ta'iz area. According to NWRA estimates, these costs are around 3–8 Rials/m^3 at present and would not exceed 23 Rials/m^3 as depletion increased the pumping lifts to 250 m in the future. In the main water-consuming sector, agriculture, marginal benefits depend on crop production functions that exhibit diminishing marginal productivity. However, the exclusion of external costs of groundwater extraction from the private marginal costs of water, combined with low pumping costs, implies that a lot of water is absorbed in crop irrigation before its private marginal costs and benefits are equalized. To make matters worse, farmers can prevent decline in marginal productivity of water by bringing more area under irrigation because the diminishing marginal productivity of water obtains only when other factors of production (including land) are held constant. Indeed, the Ta'iz region has seen considerable growth in irrigated area and the tendency is likely to continue as long as there is suitable land to be brought under irrigated cultivation.

A second issue is that the water users consider only current benefits and costs of groundwater extractions. Future benefits — which would accrue only if the current extractions were moderated — are ignored. This is because, in the absence of well defined and inter-temporally secure water rights, water users have no way of making claims in the future on water saved today. The dominant strategy, therefore, is to capture the resource now because it is likely to be depleted by others in the future. However, if institutional mechanisms existed that allowed an individual to make future claims on the water saved today then individuals would tend to compare the benefits of using water now versus using it in the future. If the discounted future benefits were greater compared to the benefits associated with use today, more water would be saved relative to the prevailing situation where resource capture by others implies that future benefits are exactly zero.

The rule of capture is essentially a consequence of the absence of well-defined water rights and, in turn, leads to market segmentation, a phenomenon that has played an important role in bringing about current water crisis. In the Ta'iz region, the farmers, the water utility, the private piped water supply schemes in the city, and the well-owners supplying pumped groundwater to tankers catering to urban and industrial clients, can all capture the resource without having to acquire the right over it because such rights do not exist. As a result, there is no market for rights over the raw water resource, which is a factor of production for water services sold on urban, industrial and irrigation water markets.[9]

[7] The external cost of groundwater abstraction is the economic cost of additional pumping imposed on all other users due to the pumping by one individual.

[8] A strategic interaction among two or more players where the players can gain only at each other's expense.

[9] The supply of water to farmers for irrigation as well as to urban and industrial consumers (by pipes or tankers) is essentially the delivery of water services embodying varying degrees of pumping, conveyances, and distribution services. The raw water that is delivered is captured and not paid for.

This has two important consequences. First, the price formation process in markets for irrigation water remains insulated from demand conditions in the urban and industrial sectors, with irrigation water services (i.e. supply of groundwater for irrigation from wells) being priced low and generally close to the pumping costs. Cheap water is a major cause of low irrigation efficiency. Second, the absence of water rights and markets for transacting them implies that voluntary exchange cannot take place. Since no one owns water (rights), no one has to be paid for it. As a result, those adversely affected by resource capture cannot be compensated, leading them to resist and in the process escalate the social conflict.

4. Decentralized water resource management options

This section considers various options[10] for addressing the water problem based on the diagnostic analysis of the previous section.

4.1 The Piguovian solution

One way of internalizing external costs is a Piguovian tax. The tax simply adds the external cost imposed on others to the price of water charged to the individual user. This forces the user to reduce abstraction. However, taxes are politically difficult to impose, and technically difficult to calculate for aquifer systems with high anisotropy, as in Ta'iz. Moreover, there is no guarantee that water saved would be easily available to other sectors in need.

4.2 Second best instruments: input taxes

A somewhat related alternative is to tax inputs that are used in the production of water. This includes diesel fuel and electricity used for pumping groundwater, as well as capital inputs, such as pumps and related equipment (Shah and Hussain, 2000). However, taxes on inputs are only a second best option, as the externality relates to the use of groundwater, rather than to the inputs used for pumping it. Moreover, in an oil exporting country like Yemen, it is politically difficult to use diesel price increases as an instrument of conservation.[11] Finally, if the well owners have local market power, an increased portion of the marginal cost of extraction would be passed on to small and generally poor farmers.[12] This phenomenon has been observed in irrigation markets in India (Shah and Hussain, 2000).[13]

4.3 Water rights and water markets

Fortunately, other approaches exist, such as creating a system of water rights that could bring about more desirable conservation and resource allocation outcomes. However, assigning water rights requires addressing issues that initially appear quite complex.

One seemingly difficult issue relates to the frequently expressed concern about potential mismatch between the needs of the users and the water rights assigned to them. Let's consider this issue. If all water users were alike, equal water rights could be assigned to them. Treating equal needs equally makes some intuitive sense. Under special circumstances, where some water users were different but not in a fundamental way, rights may still be assigned albeit with greater difficulty. For example, water rights between small and large farmers could be assigned on the basis of land holdings. This would better meet the individual water requirements of this diverse group of users.

Upon reflection it seems clear that the task of assigning rights on the basis of need would become increasingly complex as the heterogeneity of users increases. How could water rights be assigned, for instance, in a population containing both farmers and domestic consumers? The difficulty here stems not only from the absence of a common basis of assessing needs but also from the ambiguity of the concept of 'need' itself. Domestic water consumption ranges from less than 20 litres/capita/day in rural Yemen to 200 litres/capita/day in developed countries. What daily quantity represents the actual 'need'? This difficulty also arises in assessing needs within the group of farmers, given the heterogeneity in production techniques. For instance, the amount of water needed to produce a kilogram of tomatoes in a greenhouse in the Sa'adah region is different from the amount needed to grow the tomatoes in a field in Ta'iz.

The difficulties in assigning water rights on the basis of needs suggest that we might do well to look for a class of institutional arrangements that diminish the social cost arising from a somewhat arbitrary assignment of rights. Are there institutions that could accomplish this? The answer is in the affirmative. A regime of tradable water rights would allow social costs to be minimized. Markets allow high-value users to bid water resources away from low-value users, while fully compensating them. In this process, they 'endow water with an implicit value or opportunity cost' (Thobani, 1995). Users are forced to adopt water-saving technologies in an attempt to either reduce their water bills, or to trade the water at a higher price and make money. As

[10] Decentralisation here refers to 'economic decentralisation' that leaves the producers and consumers free to decide the quantities to be produced and consumed, respectively.

[11] Ward (1998) notes that diesel price increases have been 'driven by the need for macroeconomic stabilization and by structural adjustment policy rather than by a water resources conservation strategy'.

[12] Economic theory of monopoly behaviour suggests the following relationship between price and marginal cost if market power is present:

$$p = [|\varepsilon|/(|\varepsilon| - 1)]\ MC$$

where p is the price of water; MC the marginal cost; and ε the price elasticity of demand for water. For illustration, if the elasticity of demand were taken as 1.5, the price charged would be three times the marginal cost.

[13] Shah and Hussain (2000) note that well owners with diesel powered pumps in India 'tend to extract substantially higher monopoly rents' compared to well owners with electric pumps, especially if they pay a flat rate power tariff for electricity rather than a rate based on metered consumption.

water moves from sectors with low use value to those with higher use values, the total social benefit from water use is maximized. All this happens through voluntary exchange that benefits both sides and hence the social tensions prevailing in a regime characterized by resource-capture are avoided.

Does it matter at all how water rights are assigned? It most certainly does. Water is a productive resource and how it is distributed has implications for the distribution of income. Certain equity concerns can be addressed by giving due consideration to the poor during initial allocation of water rights. However, the point here is that increasing the size of the social pie (i.e. minimizing social losses through better allocation of resources) is a very different task from distributing the pie of a given size (equity). The instruments to ensure that the pie increases in size do not have to be the same as those used for distributing it more equitably.

In any case, because of the complexities involved in defining 'needs' and using them to assign water rights, a better approach seems to be to only consider basic water needs while assigning water rights. The rest should be left to market-like processes. The market would ensure that water is distributed efficiently while extreme inequities could be avoided by defining and protecting basic water needs.

5. Towards a solution: a framework for rural–urban water transfers

What is being proposed here is not water markets as such but markets in water rights. As mentioned earlier, the term 'water markets' is sometimes used to indicate what are essentially markets in water services — pumping of irrigation water, and water supply, using public or private pipe networks, or even tankers. Such markets in water services exist in Ta'iz, as in many other parts of the world, without water rights necessarily being legally defined or tradable.[14] In other words, the observed water trade does not necessarily imply the existence of a market in water rights. Neither does the mere existence of water rights automatically lead to the emergence of water markets.[15] Whether or not water trade is based on well-defined rights, however, is crucial from the perspective of rural–urban water transfers.

Typically, when water rights are not defined, secure, and legally tradable, water trade takes place mostly within the sector. Examples include exchanges of irrigation turns for surface water by neighboring farmers (e.g. Bandaragoda and Rehman, 1995) and sale of groundwater by well owners to farmers who do not own wells. There is evidence that even these exchanges improve productivity (Renfro, 1982; Meinzen-Dick, 1996). In some cases, intersectoral water trades may also take place under these conditions but on a very limited scale. For example, tankers in Ta'iz delivered roughly 1 million m^3 of water to urban consumers and industries in 1996. However, this is a very small quantity compared to total groundwater use of 41 Mm^3 (see Table 1). The rather modest volumes of these transfers and the fact that they were effected by a small number of well owners, means that their costs (depletion and declining water tables) were diffused among many users while their benefits were concentrated to a few. As a result, the latter group formed a dominant coalition that was able to prevent others in the community from blocking such transfers.[16]

When water rights are not defined, large-scale water transfers between sectors run the risk of leading to conflict, as the case of Ta'iz demonstrates. Unless those who are adversely affected by large-scale water transfers are compensated, opposition to such transfers of water remains strong. In Ta'iz, because the projections of water demands suggest that urban and industrial water needs would substantially increase in future (see Table 2), large-scale transfers from the agriculture sector would be necessary to avert another water crisis. These transfers would become possible only if they took place through a market in water rights. The usual modus operandi of so-called 'water markets', or more correctly water services markets that are characterized by resources capture, would only intensify the rural–urban conflict.

Ideally, therefore, the rural–urban water transfer should take place under a comprehensive framework that enjoys agreement of all parties. The framework proposed below, which incorporates the concept of tradable water rights, represents such a win-win situation for all sectors and may be adopted by consensus.[17]

- Clearly defined rights
  There should be clearly defined rights (for sectors and individuals within sectors), taking into account ethical considerations, such as priority for drinking water needs, and equity.

[14] For a general review of country experience in water markets see Easter and Hearne (1995). For an overview of South Asian literature, see Shah and Hussain (2000). Also see Meinzen-Dick (1996).

[15] The existence of water rights does not imply that water will be actually traded. If the water rights correspond more closely to requirements, near autarky will prevail. Moreover, Shah and Hussain (2000) provide examples where many tank systems of South India and traditional irrigation systems, *phud*, in Western India have 'completely specified, exclusive, transferable and enforceable' water rights, without evidence of extensive trade in water rights.

[16] NWRA's Stakeholders' Participation Team noted opposition by non well-owning farmers to the idea that all water rights should be assigned exclusively to the well owners (Riaz, 1999c). This suggests that the community would like to see a broader sharing of the benefits of transfers. Therefore, large-scale water transfers may not be possible if benefits are limited to well owners alone.

[17] See Riaz (1999c) for an earlier version of the framework and a discussion of sub-catchments of upper Wadi Rasyan where this framework might be implemented.

- Water should be allocated through market-like processes
  Except for lifeline water supplies (e.g. minimum water needed for drinking and sustaining health/well-being), the remaining water should be allocated through market-like processes. The objective would be to allocate water towards high-value uses and away from low-value uses.
- Direct compensation
  The water rights should be tradable and to the extent possible, there should be direct compensation of individuals willing to transfer their water rights to others (e.g. to the urban sector). This compensation should be commensurate with the rights transferred. Provision of public goods (roads, electricity, schools, water supply schemes, etc.) is an indirect form of compensation.[18] While this is not to be ruled out, the basis of calculating compensation should remain the actual right transferred.
- Water transfers must be verifiable
  It should not be possible, for instance, for farmers to agree to sell certain water rights and then continue to abstract as much groundwater for irrigation as before. Those who agree to transfer their water rights must reduce their water use for the stipulated period.
- Mechanism for monitoring compliance
  A mechanism must be devised for monitoring compliance and punishing violators. This mechanism could involve government agencies but should also include local communities, as they have an informational advantage and can bring social pressure to bear on violators.
- Local communities to participate
  Local communities should actively participate in designing the rules and mechanisms that would govern rural–urban water transfers. These rules and mechanisms should be adopted with the consent of the local community.
- National regulatory agency
  A national regulatory agency should have an oversight role in rural–urban water transfers to ensure sustainability of extraction and equity. In Yemen, the National Water Resources Authority (NWRA) would perform this role. The agency performs technical functions, such as water resources assessment, that enable it to keep the larger water resource situation and its dynamics in view while making decisions over allocation.

[18] In return for the Habir concession, the communities received a package of public goods consisting of the following. (i) Two dams for recharge and storage; (ii) four irrigation wells and pumps; (iii) two pumps for local cooperatives; (iv) village water supply schemes for "Habir and Al-Haima", with an unspecified number of villages to be served; and (v) three rooms for school in Habir. The compensation offered was not sufficient to offset actual losses of farm income due to water transfers. As the compensation was in the form of public goods, there was no relation between the loss in farm income suffered by those who could potentially reduce extractions and the benefits provided by the deal. For the same reason, the benefits could not be withheld from those who failed to comply. An agreed monitoring programme to verify reductions in the groundwater pumping as agreed by the community did not accompany the deal.

Table 3. Returns on water use in agriculture (selected crops) in Al-Haima zone

Crop	Average returns on irrigation water (Rials/m^3)
Qat	17–23
Summer maize	1–3
Summer sorghum	1–3
Winter maize	7–13
Winter potato	25–37
Winter tomato	15–21

Source: The range of returns on water use for various crops is obtained from estimates presented in Riaz (1999a) and Al-Shami *et al*. (2000).

Why might this work, especially when even the existence of well-defined water rights does not guarantee that they would be actually traded? At least part of the answer lies in the gains from trade. In Ta'iz City, the willingness to pay for water of urban and industrial consumers is much higher than returns on agricultural water use. In 1997, urban consumers and industries were paying around 285 Rials/m^3 for water delivered to them by tankers (Handley, 1999). Compared to this, returns on groundwater used for irrigating cereal crops, as shown in Table 3, were in the range of 1–3 Rials for summer maize and sorghum, and 7–13 Rials for winter maize. The highest returns on water were for Qat (17–23 Rials/m^3) and potatoes (25–37 Rials/m^3). Therefore, if farmers are able to free up some water by adopting more efficient irrigation technology and by changing cropping patterns, the gains from transferring water to high-value non-agricultural uses could be substantial. These gains could more than compensate farmers for any loss of income, provided transfers take place on the basis of voluntary exchange of water rights rather than through resource capture by the providers of water services.[19]

6. Issues in implementation

Even when potential gains from trade exist, there are practical difficulties in implementing a system of tradable water rights[20]. Thus, there may be difficulties in:

- Initial allocation of water rights, and dealing with *de facto* rights;
- Measuring water and enforcing contracts;
- Building the necessary infrastructure;
- Dealing with third party effects and protecting the environment; and
- Avoiding monopolistic practices.

[19] Well-owners are suppliers of an intermediate service — pumping — used in the production of water, or in production of water delivery service by tankers catering to urban and industrial users.
[20] See for example Thobani (1995), and Easter and Feder (1996).

6.1 Initial assignment of water rights

Let us consider the initial allocation of water rights along with the issues of 'basic water needs' and equity. In Ta'iz, no one has legally recognised water rights, however, those who can afford to drill wells may take as much water as they need. As a result, current groundwater use is far in excess of natural recharge, as Table 1 clearly shows. This raises the difficult question of how to deal with existing *de facto* rights. If all current *de facto* rights were legitimised, unsustainability would get 'written into the law'. On the other hand, aiming for strict sustainability in the short term may cause disruptive changes in local production systems and the local rural economy.[21]

A practical solution would be to first develop a consensus among the local communities in each zone on a timeframe for groundwater extraction that is more sustainable than recent practice. The timeframe could be such that progressively greater degrees of sustainability are aimed for, thus allowing time for the production system to adjust.[22] There is already a fairly strong consensus in the Ta'iz region that groundwater use should be more sustainable; nearly 80% of the farmers surveyed in 1998 said that depletion needed to be controlled (Riaz, 1999b). Thus, agreeing on a more sustainable timeframe for total groundwater use should not pose insurmountable difficulties.

The next step would be to translate the timeframe into annual benchmarks or targets for total volumetric groundwater extraction. NWRA could help in this process by making available to the stakeholders the water resource information it collects and the results of the water resource assessment carried out for the region. Based on such assessments, NWRA could also determine which zones would be allowed to make transfers of water to the city.

Individual tradable water rights could then be defined for any given year with reference to that year's target groundwater extraction for the zone. This brings us to two crucial issues:

- What should be the basis for allocating water rights among the water users?; and
- How should the ethical concerns regarding distribution of water rights be addressed?

In the Ta'iz region, the primary water users are farmers (who use the bulk of the water currently being extracted), domestic consumers, and industry. Distribution or equity concerns largely address the ability of poor domestic consumers to afford the necessary minimum amount of water should the price increase under the tradable water-rights regime.

The water rights for farmers can be defined on the basis of irrigated land holdings. Most of the irrigated land in the Ta'iz region lies in the wadi (valley) beds, although some irrigated fields may also be found along the sides of the wadis, irrigated by piped groundwater pumped from the wadi. Land-use studies already conducted in the region (see Dar-El-Yemen, 1999) provide a reasonably good estimate of the irrigated area in each wadi, which can be apportioned among individual owners as their base irrigated area, using the cadastral records. For a given zone or sub-catchment, the individual's annual water rights could be defined as the ratio of the total target groundwater extraction for that year and the total base irrigated area in the zone. Thus a landowner's annual volumetric water right would be proportional to his/her base irrigated land holdings.[23]

Although, the initial assignment of water rights is proposed to be on the basis of land holdings, water rights are not to be tied to land. The water right holder would be free to trade all or part of his/her water right for the year. It is advisable that farmers should be allowed to sell their rights only for the current year. This would prevent distress sales of permanent water rights by poor smallholder farmers and would also guard against acquisition of market power through buyouts by large landed or commercial interests.

The above scenario assumes that all target groundwater extractions could be allocated to agriculture. In other words, it ignores the distribution of water rights among sectors. As noted in section 4 above, the distribution of water rights has welfare implications for the users. For instance, the existing (*de facto*) water rights are currently capitalised into the value of agricultural land. Therefore, a major reallocation of rights to other sectors would cause capital losses to existing farmers and would likely meet with strong opposition from them. Domestic consumers would face higher water tariffs if, in addition to paying for pumping, conveyance and distribution, they also had to pay for the raw water. The same is true for industries.

How, then, can these conflicting claims be reconciled? The main argument in this article is that rather than trying to continuously match water allocations to changing water needs of economically and demographically dynamic sectors, it is far more important to make an initial assignment of tradable water rights while avoiding extreme inequities. In the process of assigning rights, therefore, the only negative welfare effects that need to be considered are those associated with the excess burden of purchasing water rights on the poor. Consequently, the above scenario of allocating target groundwater extraction needs to be modified only

[21] The term strict sustainability is used in the sense of total annual water use (net of deep percolation) being equal to annual natural recharge.

[22] Adjustments could involve changes in cropping patterns and adoption of water conserving technologies and practices.

[23] Under this scheme, the only direct allocation of water right to landless residents in the area is the minimum set aside allocation to cover basic needs. However, one cannot discount the possibility that land lease contracts could evolve so that landless tenants are able to lease land-and-water packages through either fixed rent or sharecropping tenurial contracts. Interlocking of land and water contracts is common in Yemen and many other parts of the world.

by making provision for a water allocation set aside for lifeline water supply for the poor. This would be subtracted from the target groundwater extraction before apportioning the rest of it among individual farmers according to their base irrigated area.

If industries need water from a certain zone, they would have to buy it. The same would apply to the city, except for its entitlement to an initial grant of lifeline allocation. Of course, water costs to industries would increase as a result of this arrangement. But as water costs currently make up a small proportion of the gross value of industrial production in the Ta'iz area, an increase in this cost would not have major welfare implications.[24] It might however induce industries to start recycling water, which is not the general practice in the Ta'iz region at present, partly because of the relatively low price of water.

Urban consumers, buying water from the public utility NWSA, would also face a higher water price. Although cheap, the supply from the utility is severely rationed at present and it is also of unacceptable quality due to the fact that freshwater is being mixed with contaminated water from wells in the Hawban-Hougala area.[25] The existence of severe rationing implies that the virtual price of water to households connected to the public utility network is much higher than the nominal price charged (the water tariff). An approximation of this virtual price is the price paid for tanker water (285 Rials/m^3) as this is what households are effectively willing to pay at the margin of use. If the proposed rural–urban water transfers mechanism could make additional supplies of good quality water available, even at a somewhat higher price than the current average tariff charged by the utility (24 Rials/m^3, according to Handley, 1999), the welfare of the urban consumers could possibly improve.[26]

The above mentioned outcome with respect to welfare of urban domestic consumers is more likely to materialise in the presence of allocation for lifeline supplies. However, defining that allocation may require serious negotiations among stakeholder groups. The urban domestic water use in Ta'iz is about 36 litres/capita/day (NWRA, 2000) while the rural domestic use is only 16–20 litres/capita/day (Riaz, 1999b; Mullick, 1978). Given the inadequate levels of rural water use, it is unlikely that rural communities would agree to any set-aside allocation for the city alone that meets standards such as the WHO recommendation for minimum water needs (28 litres/capita/day, cited in Handley, 1999). Therefore, the principle that needs to be applied is that the per capita set-aside quantity should be the same for both rural and urban areas. This may make negotiating the set-aside allocations somewhat less difficult, although it would still not guarantee that the set-aside would meet an objective criterion of 'minimum needs'. But that should not be considered a major stumbling block, as the set-aside allocation is only one of several instruments available for lessening the economic burden of water purchases on the poor. Other instruments, such as cross-subsidies for the poor built into the water tariff structure, or a water stamps programme targeted at them, could help achieve the same equity objectives once the water rights issue has been resolved.

6.2 Monitoring water use and enforcing water rights

For the proposed framework to succeed, it is essential that water extractions take place on the basis of water rights assigned to individuals and that if the original right holders trade their annual water rights, they reduce their extractions accordingly during the year. This requires monitoring and enforcement. The former would involve measuring groundwater extractions. For this purpose, wells with motors should be metered. However, this is just one component of the required monitoring. NWRA must also engage in hydrometeorological monitoring to accurately estimate groundwater recharge, extractions and groundwater level decline on an annual basis. This information would be crucial in ensuring that the region stays within the target time frame of extraction agreed to by the local community. Although the enforcement of a water rights regime would require a legal basis, the law alone would not be enough. The enforcement has to be a shared responsibility between the community and NWRA.[27] As noted earlier, communities have a comparative advantage vis-à-vis government agencies in that they can bring social pressure to bear on violators. The local community would participate in the monitoring process and its members could be trained to undertake simple monitoring

[24] According to Sayagh (1998), the industries in Ta'iz region used 4.2 Mm^3 of water in 1995 and produced a gross value of 43,159 M Yemeni Rials. About 0.5 Mm^3 were delivered by tankers costing about 285 Rials/m^3 and the remaining 3.7 Mm^3 were pumped from industries own wells. Pumping costs for industrial wells is between 3 and 8 Rials/m^3. Even if we take 10 Rials as the upper limit, the total water cost would be of the order of 177 million Rials of which about 140 million Rials would be for buying tanker water. Thus water costs are less than 1% of the gross value of industrial production.

[25] During the 1995 water crisis, NWSA supplied water only once in 40 days. The situation improved subsequently but even in 1997, the supply frequency was once in 20 days (Handley, 1999) indicating that water supplies remain severely rationed. Much of the quantitative improvement in water supply was achieved by mixing freshwater with poor quality water from well fields in the Hawban-Haugala area that had an electrical conductivity of some 5,000 μS/cm and had been previously closed. In a household sample survey conducted in 1997 in Ta'iz City, 69% of the respondents who were connected to NWSA water supply network described the quality of NWSA water as being 'inadequate' (Handley, 1999).

[26] Assuming that low value agricultural crops (e.g. cereals) would be the first to release water, and given the large gap between what the consumers pay at the margin of use (for tanker supplies) and returns on most agricultural uses (Table 3), the additional supplies may come at a relatively affordable cost.

[27] Katon *et al*. (2001) present the concept of devolution of natural resources management that involves 'transfer of rights and responsibilities to user groups at the local level'. The authors note that 'the actual nature and extent of co-management arrangements are likely to depend on local capacity to undertake certain roles and functions'.

tasks, such as groundwater level measurements. Moreover, since the community members live in the area where exploitation is taking place, they can monitor more effectively and at minimal cost.

6.3 Third-party effects and environmental protection

In many uses of water, particularly irrigation, a part of the water used returns to the aquifer through percolation, and can be utilised by others. However, transferring water to the city located outside the sub-catchment (as is the case with transfers from Al-Haima and Dhi Sufal sub-catchments in Ta'iz) means that the return flows are lost to users in the zone where the transfers originate. On the other hand, increased wastewater flows are generated by the city that may pollute nearby peri-urban areas if no treatment of this water is undertaken. Both these problems need to be addressed.

The loss of return flows can be dealt with by allowing transfers of water net of the return flows. For example, if on average α % of water used for irrigation in a zone percolates back into the aquifer, the city would be allowed to transfer out of the zone only $(100 - \alpha)$% of the water right purchased by it. Thus, transfers would be limited to an amount equivalent to the consumptive use.

As the city consumes more water, it also generates more wastewater. Only about 35% of the households in Ta'iz City are connected to the sewage system, the rest rely on cesspits that leak into the aquifer (NWRA, 2000). The treatment of wastewater collected by the sewerage system is inadequate. The problem is compounded by untreated wastewater from industries located in and around the city. As a result, aquifers in the Central and Hawban zones are severely polluted.[28] It should be noted that, although transfers would ease the water scarcity and contribute to generating more wastewater, they are not the primary cause of environmental degradation. Degradation occurs because environmental protection laws are not implemented. Such laws need to be enforced, whether or not water transfers are based on a tradable water rights regime (Thobani, 1995). To a great extent, tradability of water rights would induce industries to recycle water as an alternative to buying rights to the water they need. This in turn would limit their effluent discharge and help protect the environment.

6.4 Infrastructure

A water conveyance and distribution infrastructure is needed regardless of whether water is appropriated by the urban agency, as in the present situation, or bought on a water rights market. Mains already exist in the region to carry water to Ta'iz City from wells located in the Dhi Sufal, Al-Haima, and Hawban zones. New pipelines would be needed only to transfer water from the Dhabab zone or from outside the upper Wadi Rasyan catchment. The distribution network within the city is quite old and as much as 40–45% of the water is lost to leaks (CES, 1997:27). If water rights were to be bought by the city, rehabilitation of the distribution system would get a much higher priority, as plugging the leaks would be an alternative to buying water.[29] The same would be true for domestic consumers, many of whom have overflowing water tanks. Thus tradable water rights are likely to induce more investment into the water supply and distribution infrastructure.

6.5 Avoiding monopoly

If water rights were assigned to individuals, no single seller would have paramount market power, especially if large-scale farmers and commercial interests were prevented from acquiring permanent water rights by buying out smallholder farmers. The objective of avoiding monopoly formation would be achieved if rights were assigned for one year at a time and water trades registered only for that year, as proposed above.

However, the problem of market power of well owners vis-à-vis buyers of irrigation water services is less straightforward. Note, however, that under the tradable water rights regime, the right belongs to the buyer of irrigation services, not to the well owner. In contrast to the present situation, the well owners under the proposed regime would have control only over the supply of pumping services, not over the water itself, which they must acquire from the farmer holding the water right. Moreover, the latter would have the option of reducing their area under irrigation and selling all or part of their water right to the city. This would likely increase their bargaining power in relation to well owners and limit the expropriation of irrigation surplus. Nevertheless, this is a less explored research area; future research on these issues is expected to yield useful insights.

6.6 Legal and institutional pre-requisites

A tradable water rights regime cannot be implemented without the support of law. At present, Yemen does not have an approved water law. A draft was presented to Parliament for ratification, which is now being revised. It is expected that the revised draft will be re-submitted for approval within the next few months. The current draft allows the separation of water rights from land as well as their transfer. Ratification of the water law containing these provisions is a necessary condition for the implementation of the rural–urban water transfers framework discussed in this article.

In addition to the legal pre-requisites, the successful implementation would also depend on community participation.

[28] Water from many wells located in these zones is unfit for human consumption and waterborne diseases are common among people living in the area.

[29] There is a limited rehabilitation programme being carried out at present but it does not cover the whole city.

The Ta'iz region has seen sporadic community initiatives for dealing with uncontrolled groundwater extractions.[30] These were mostly localised in nature and were not aimed at addressing the rural/urban water transfer issue.[31] Helping the communities to organise themselves into water users associations could ensure effective community participation. WUAs may be formed at the sub-catchment level and would consist of elected representatives of water users. Water users associations could then negotiate with NWRA regarding the target time frame of groundwater extractions; methods to ensure compliance with the water rights regime by individual water users; resolution of conflicts among users. Water users associations could also negotiate with the city regarding the quantity of water to be transferred and its price. It is important that the associations be registered and governed according to clearly defined laws and bylaws. The formation of water users associations could be aided by an NGO that would act as a catalyst for community mobilisation, in addition to 'facilitating the building of organisational capacity and leadership' (Katon *et al*., 2001).[32]

7. Conclusions

This article has traced the history of water resources development in the Ta'iz region and showed that the traditional command and control approach, involving forcible appropriation of resources, cannot work in the future. The diagnostic analysis undertaken of the Ta'iz water problem suggests that a solution is likely to be found through designing decentralised resource management mechanisms. The article has considered various decentralised policy options for more sustainable water resources management, and particularly for improving intersectoral water allocation. These include:

- Piguovian taxes on water to internalise the external cost associated with declining water tables;
- Input taxes, on e.g. fuel and equipment used for pumping groundwater; and
- Tradable water rights.

The article has demonstrated that from the standpoint of the political economy, a tradable water rights regime is the most promising option. It represents a win-win solution that would both facilitate intersectoral water allocation and improve use efficiency. Groundwater rights can be assigned by first agreeing with the community on a target time path of extractions and then using base irrigated area in the catchment to allocate individual yearly water quotas according to land ownership in the base irrigated area. The article has argued that there is no need to continuously adjust water quotas to match changing sectoral needs as tradability of water rights would insure that water would move to the highest bidder. However, it is recognised that even under a tradable water rights regime, the initial allocation of water rights has welfare implications. Therefore, the paper recommends a 'set-aside allocation' for lifeline supplies for the poor, in addition to built-in cross-subsidies in tariff structure or targeted water-stamps programmes. It is noted that, the prerequisites for a tradable water rights regime include a water law that allows separation of water rights from land ownership and the transferability of water rights. Also needed are community organisations that would be involved in co-management of water resources in their respective regions.

Finally, the article focuses on only one aspect of water management — rural–urban transfers. A more comprehensive water management initiative needs to involve many more aspects, such as demand management measures, supply augmentation measures, policies to reduce population pressure and create non-agricultural employment opportunities (see for example, NWRA, 2000).

Acknowledgements

A short version of the article was presented at a seminar organized by WEC at Sana'a University, Sana'a, Yemen, Oct 28–29, 2000. The author would like to thank Ahmed Ali Al-Shami and Abdullah Saleh Saif for their collaboration in preparation of the presentation. Special thanks are due to four anonymous referees for their extremely valuable comments. Thanks are also due also to Mr Tushar Shah for providing some very relevant literature. The author alone remains responsible for any errors in the article.

References

Al-Shami, A., Riaz, K., Saghir, N., Al-Dubby, S.A., 2000. Al-Haima zone policy simulation model. Unpublished report. National Water Resources Authority, Sana'a, Yemen.

Bandaragoda, D.J., Rehman, S.U., 1995. Warabandi in Pakistan's Canal Irrigation Systems: Widening gap between theory and practice. Country Paper, Pakistan No. 7. International Irrigation Management Institute, Colombo, Sri Lanka.

CES, 1997. Rehabilitation of the town distribution network, Ta'iz. Program for reduction of water losses in selected NWSA towns. National Water and Sanitation Authority, Yemen.

[30] Examples include the collective action by the Al-Sinah community to protect their water supply sources from drying up due to irrigation development (World Bank, 1997). The community bought up land near their water source, drilled wells and capped them. This effectively pre-empted irrigation development because the well-spacing restrictions prevalent in the region allowed no drilling within 500–1000 m of existing wells.

[31] The only exception is the so called 'compensation package' for Habir and Al-Haima but, as mentioned above, even this was originally designed to obtain community's consent for exploratory drilling rather than for providing compensation for transfer of water out of the region. The design of the compensation scheme failed to provide adequate incentives for monitoring and enforcement of water management measures (particularly reduction in extractions) agreed with the community.

[32] The idea of involving an experienced NGO in community mobilisation efforts was strongly endorsed during several stakeholders' meetings organised by NWRA in the Ta'iz region during August 2000.

Cestti, R. 1989. Water Resources: problems and issues of water supply and sanitation sector. INUWS, The World Bank, Washington, D.C.

Easter, W.K., Feder, G., 1996. Water institutions and economic incentives to ameliorate market and government failures. Staff Paper Series P96-14. Department of Applied Economics, College of Agricultural, Food and Environmental Sciences, University of Minnesota. St. Paul, MN.

Handley, C. 1999. 'Household water use survey, Ta'iz, Yemen'. Final Report. Sustainable Water Resources Management Program (YEM/97/200), National Water Resources Authority, Sana'a, Yemen.

Hardin, G., 1968. The tragedy of the commons. *Science* 162: 1243–1248.

High Water Council, 1992. Regional water requirements for different water-consuming sectors. Final Report, Vol. V. Technical Secretariat of HWC, UNDP/DESD Project YEM/88/001, Sana'a, Yemen. June.

Katon, B., Knox, A., Meinzen-Dick, R., 2001. Collective action, property rights, and devolution of natural resources management. Policy Brief Number 2. CGIAR Systemwide Program on Collective Action and Property Rights. International Food Policy Research Institute, Washington, D.C. January.

Meinzen-Dick, R. 1996. Groundwater markets in Pakistan: Participation and productivity. Research report No. 105. International Food Policy Research Institute, Washington, D.C.

Mullick, M.A., 1987. *Socio-economic aspects of rural water supply and sanitation: A case study of Yemen Arab Republic*. Book Guild Ltd., Sussex, U.K.

National Water Resources Authority (NWRA), 1997. Well inventory in upper Wadi Rasyan. Technical Report No. 1. Sustainable Water Resources Management Program (YEM/97/200), National Water Resources Authority, Sana'a, Yemen.

National Water Resources Authority (NWRA), 2000. Water resources management action plan for Ta'iz. Sustainable Water Resources Management Program (YEM/97/200), National Water Resources Authority, Sana'a, Yemen.

Renfro, R.Z.H., 1982. Economics of actual control of irrigation water in Pakistan: A pilot Study. Unpublished Ph.D. Dissertation. Colorado State University, Fort Collins, Colorado.

Riaz, K., 1999a. Agriculture and water use in the Ta'iz region. PPS Report. Sustainable Water Resources Management Program (YEM/97/200), National Water Resources Authority, Sana'a, Yemen.

Riaz, K., 1999b. Socio-economic study of the Ta'iz region. PPS Report. Sustainable Water Resources Management Program (YEM/97/200), National Water Resources Authority, Sana'a, Yemen.

Riaz, K., 1999c. Water Resources Management Strategies in the Ta'iz Region. PPS Report. National Water Resources Authority, Sana'a, Yemen.

Sayyagh, A.K., 1998. Industrial water requirements for Ta'iz region. PPS Technical Note Series. Note # TN-98-02. National Water Resources Authority, Sana'a, Yemen.

Shah, T., Hussain, I., 2000. Groundwater markets and agricultural development: A South Asian overview. Unpublished report. International Water Management Institute, Colombo, Sri Lanka.

Taher, M.S., 1998. Domestic water demands and wastewater loads in Ta'iz region (upper Wadi Rasyan). PPS Technical Note Series. Note # TN-98-03. National Water Resources Authority, Sana'a, Yemen.

Thobani, M., 1995. Tradable property rights to water: How to improve water use and resolve water conflicts. FPD Note No. 34. The World Bank, Washington, D.C. February.

Van der Gun, J., 1999. Towards an action plan for water resources management in Ta'iz region, Yemen. Mission Report No. 5. Sustainable Water Resources Management Programme (YEM/97/200), National Water Resources Authority, Sana'a, Yemen.

Ward, C., 1998. Practical responses to extreme groundwater overdraft in Yemen. Paper presented to the International Conference Yemen: The Challenge of Social and Democratic Development. Centre for Arab Gulf studies. University of Exeter, U.K. April.

World Bank, 1997. 'Yemen: Towards a water strategy'. World Bank Report No. 15718-YEM. The World Bank, Washington, D.C.

World Bank, 1998. Yemen: Local water management in rural areas- a case study. Draft Sourcebook prepared for Ta'iz pilot Water Supply Project. World Bank, Resident mission. Sana'a, Yemen.