Special Issue

“Urbanization & periurbanization: Challenges for water governance in south Asia”
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Rural to urban groundwater market: demand management option vs. environmental sustainability

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Groundwater market, demand management, peri-urban, environment, sustainability

Abstract
Providing adequate water to meet the booming urban need is a great challenge for the local administration in developing countries. Generally, there is a huge supply-demand gap in the public water distribution in urban areas. This might be mitigated through transferring water from peri-urban or village aquifers through the water market. However, the continuous transfer of groundwater has led to the depletion and degradation of groundwater, and its implications on the regional environment and the livelihood of the village poor are of major concern.

This paper examines the significance of groundwater in meeting the demand in various sectors (including urban needs), particularly during water resources vulnerability, the water market as a demand management option, and various impacts of rural to urban groundwater transfer, based on a study in Chennai. The paper also argues the need for formalizing the groundwater market in the context of its pressing need in supplementing the urban water supply, and the challenges of environmental and socio-economic sustainability in the villages. In this regard, a rigorous scientific analysis of the dynamics of groundwater in the water marketed areas, the strict enforcement of groundwater laws, applications of economic instruments, and an active collaboration among different stakeholders including the government departments, are suggested.

Introduction
Recently, most of the developing countries have been experiencing rapid urbanization. The trade liberalization policies adopted by these nations, during the globalization phase, have given a boost to many urban-based economic activities in the industrial and service sectors. According to Lundqvist et al. (2003), ‘Virtually the entire population growth in the world during the coming decades will occur in or be concentrated in urban agglomerations and most of it in less developed countries.’

The increasing population and concentration of various economic activities, in urban areas, has led to an increase in demand for water from the non-agricultural sectors. At the same time, to meet the ever growing basic needs of people, the production of more food grains and other agriculture products is also required. This has led to an increasing demand for water in the irrigation sector.

The problem is further compounded by environmental pollution due to the indiscriminate waste discharge from the various sectors.

Under these circumstances, it is more important than ever before to use water efficiently with appropriate allocation strategies. Generally, the solution to water scarcity problems is centred on two strategies:

(a) The supply side management like watershed development and water resources development, and

(b) The demand side management by the efficient use of the available water, both in the short and the long run.

Though there are a number of demand management options available, one of the management strategies adopted either formally or informally across regions by the groundwater market, is reallocation of water, particularly in regions where water scarcity is acute (Palanisamy 2008).

Normally, urban water supply schemes target surface water such as rivers, tanks, or reservoirs as sources, and provide adequate treatment before distribution. But in many developing cities, the Water Board is not able to provide an adequate quantity of protected water, particularly in the summer months, when the flow or storage of the surface sources reduces.
Besides the urban sprawls and newly emerging commercial institutions industries are also struggling to obtain water through public supply. Hence, there is a huge supply and demand gap.

In these circumstances, the aquifers of the peri-urban villages act as a supplementary source or an effective demand management option, and huge quantities of groundwater are transferred to the city. In some instances, the government itself makes arrangements to transfer groundwater through pipelines or tankers. More often perhaps, a substantial volume of groundwater is transferred by private parties, and an informal private ‘water market’ of different magnitudes functions in most of the third-world cities.

The continuous extraction and transfer of groundwater from peri-urban areas to the city adversely affects the water table and village activities in many locations, where the rate of extraction exceeds the rate of recharge. The impacts are more on the poor or marginal farmers and agriculture labourers, who are not in any way involved in the water business. Moreover, whenever the water table goes down they are not in a position to invest in deepening a well or digging a new one. Due to this, the poor are denied accessibility to groundwater, leading to major water rights and equity issues. Hence, groundwater extraction from rural and peri-urban areas to meet urban demand needs to be examined in a broader perspective.

The paper emphasizes the need for management of groundwater in peri-urban areas, considering its significance as an urban demand management option as well as its sustainability, through a comprehensive study in Chennai, one of the metropolises in India. The research was carried out by the author in connection with the Crossing Boundaries project, organized by the Centre for Water Resources, Anna University Chennai. Information was gathered through secondary sources and primary studies. Detailed field investigations were carried out, and information gathered through interviews (with researchers, government officials, water sellers, and affected parties in villages, packaged-water company owners, and tanker operators) and focused group discussions with different stakeholders.

Groundwater resources: competing use and emerging challenges

Throughout history groundwater has been integral to human life and livelihoods, and for stable agricultural production in the face of water resources variability. But groundwater stock (aquifer) is only a small fraction of the overall water availability, and is not evenly distributed around the world. Of the total annual precipitation of 577,000 cubic kilometres (km³) per year, 79% falls into the ocean, 2% into lakes, and 19% on land. Most of it evaporates or runs off into streams and rivers. Only 2,200 km³ (2%) is infiltrated into aquifers as groundwater (UNESCO 2009).

Socio-economic drivers of groundwater development or extraction showed substantial geographic differences, unrelated to the resource availability. Agricultural demand for groundwater has often been spurred by both explicit and hidden subsidies for rural electrification, irrigation equipment, and well construction. In South-Asia, for instance, subsidized rural electrification to meet irrigation demands, has been a key driver of groundwater use, especially in dry land areas with no surface water services (UNESCO 2009). Besides, the progressive adoption of precision agriculture (requiring on-demand, just-in-time irrigation) has considerably intensified groundwater use and boosted its productivity. Broadly, the drilling, pumping, and well maintenance services have progressively reduced the cost of groundwater exploitation.

Apart from irrigation, groundwater is also a major source for domestic (both rural and urban) and industrial water supply around the world. In the urban category, not only mega-cities but also thousands of medium-sized towns depend on groundwater. Cities like Beijing, Dhaka, Lima, Lusaka, and Mexico are located on or near major aquifers, and urban water supply depends heavily on groundwater.

In certain cities (for example, Bangkok, Buenos Aires, and Jakarta), the level of groundwater has fallen considerably as a result of aquifer depletion, saline intrusion, or groundwater pollution. These trends have tended to obscure the mushrooming growth over the past 10-15 years of private self-supply from groundwater by residential, commercial, and industrial users in Latin America, and South and South-East Asia (UNESCO 2009).

Groundwater accounts for more than 30 per cent of the urban water supply (and a higher proportion by a number of consumers) even in many cities and towns far from major rivers. Competition over groundwater resources between urban and rural users, and the
emergence of a water market are now becoming more apparent. Expanding municipalities and industrial and commercial activities in peri-urban and linked rural areas are competing with agriculture for groundwater. The heavy private use of groundwater in urban and peri-urban areas for mitigating their ever increasing demand complicates the operation of water utility services (both water supply and sanitation). African cities are increasingly using boreholes to improve water security, with the aim of easing pressure on the water facilities in densely populated suburbs (UNESCO 2009).

Local aquifer studies concluded that, where groundwater services are in heavy demand, much of good quality groundwater has already been used. Contemporary recharge to shallow aquifers has become seriously (perhaps irrevocably) polluted, and relaxing water abstraction and pollution pressure on aquifers will take considerable time (UNESCO 2009). According to Foster & Chilton (2003), the development of the power-driven pump in the mid 20th Century led to the emergence of many groundwater-dependent economies, and recently to warnings of the potentially adverse impacts of excessive abstraction and aquifer pollution.

Aquifers that are shallow and ‘open’ to regular and dependable recharge are more vulnerable to pollution from agrochemicals and urbanization (sewage and industrial effluents). Generally, precision agriculture and large-scale commercial farming are likely to be located near urban areas, and they primarily depend on groundwater and use large quantities of chemical fertilizers, pesticides, and fungicides, which also contaminate the shallow groundwater.

Aquifer depletion and degradation have far-reaching implications including public health and resource sustainability. They also adversely affect economic growth in many parts of the world. A recent study by the World Bank (2007) in the Middle East and the North African region estimates that groundwater resource depletion has substantially reduced the GDP in some countries -Jordan by 2.1%, Yemen 1.5%, Egypt 1.3%, and Tunisia 2%. In brief, the reductions in groundwater stocks appear to have been translated into reduced economic productivity of water.

In India, groundwater resources play a significant role in meeting the ever-increasing demands of the agricultural, industrial, and domestic sectors, and their extraction has witnessed a phenomenal growth over the last five decades. At present, more than 85% of the domestic water supply in rural areas, about 50% of the water requirements in urban areas (domestic and industries), and more than 55% of the irrigation water requirements are being met from groundwater (Romani 2007).

Despite this, proper plans for scientific development of the resource are lacking. Allocation and management of groundwater, and extraction are mainly done by private enterprises. The unscientific and inefficient use of this vital resource contributes to its increasing scarcity, reflected in a steep decline of water levels and, in certain situations, a sharp deterioration in the quality of water. The scenario is critical now and there is little scope for the future development of groundwater. In Tamil Nadu, out of 358 assessed blocks only 145 (38%) are safe, 57 (15%) are semi-critical, 33 (9%) are critical, and 142 (37%) are over-exploited (Romani 2007).

**Groundwater market: as a demand management option**

Any resource when it is scarce, like water, gains economic value. Once the basic human and environmental water needs have been met, the remainder should ideally go to where water has the highest value to society. But this may not be the case in a water market.

The emergence of markets for water is determined by several socio-economic and cultural factors, and functions in a slightly different manner from markets for other commodities and inputs (Palanisamy 2008). Water markets are typically spontaneous (initiated by private individuals to achieve mutual gains), informal (transaction of water takes place without any legal bindings and for the mutual benefit of buyers and sellers), unregulated (no strict regulation is followed), localized (mostly functioning at the village or regional level), fragmented (geographical separation of sellers), and seasonal (demand varies across seasons) (Shah 1986).

Water markets in India are highly irregular, and prices are determined by the marginal costs of pumping and the elasticity of the water demand. Normally sellers enjoy the monopoly, as there is no immediate alternative option available for buyers to obtain water.

The literature on groundwater markets ranges from highly positive ones confirming that
groundwater markets are the ‘vehicles of poverty alleviation’, to those that accuse them of ‘creating water-lords’ and appropriating the surplus from the poor (Palanisamy 2008).

In a broader sense, positively speaking, water markets ensure efficiency and equity, and thereby generate adequate social benefits to society. They play an important role in the re-allocation of resources from surplus to deficient areas, and increase water productivity. The major argument in favour of the water market in the agricultural sector (rural to rural) is that it helps to access the resource by landowners without wells, and increase crop productivity, employment, and livelihood options for the poor and the landless.

It also helps in the improvement of the water quality by transferring water from surplus areas with high drainage problems to scarcity areas, thereby reducing many quality-related problems like salinity. Hence, the rural to rural (within the agricultural sector) water market is less controversial than the rural to urban (inter-sectoral) one.

The rural to urban groundwater market commonly exists adjacent to large urban areas and medium-sized towns. The transfers here typically involve the sale of water by well owners (generally farmers) either directly to industries or to tanker companies, which then supply it to end-users in urban areas, such as industries, commercial establishments, and households. In other words, it is an inter-sectoral transfer of water.

This kind of water market will lead to social inequality in a situation, where water sellers have a monopoly of the market, and have a hold of a major share of the buyers’ profit too because of the sale of water. As more people resort to water selling, the water market can cause excess pumping of water, making the groundwater aquifer more prone to depletion. This will pose a challenge to achieve sustainable water management and to ensure intergenerational equity to resource access, particularly in water scarce regions (Palanisamy 2008).

Recently, particularly in developing countries, the increasing demand for water for non-agricultural purposes has compelled a diversion of adequate water from the agricultural sector to non-agricultural users on a priority basis, which has led to the growth of an informal water market among these sectors. Despite significant restrictions on the tradability of groundwater, the informal water market has developed in response to increasing water scarcity, and to the differential value of water across sectors.

That is why active trading takes place between the agricultural and urban sectors across the world. The market serves the useful function of supplying water to users who otherwise would not be served by the highly subsidized municipal water systems. However, the market would be far more efficient if legal restrictions and the excessive electricity and municipal water subsidies were removed (Palanisamy 2008).

A study carried out by Prakash (2012) at the peri-urban area of Hyderabad revealed that tanker water comes from water-rich peri-urban areas, and this market has been growing over the last two decades. During summer, when water demand increases, there are reports of conflict between water sellers because this mechanism operates in such a fashion that the water-selling intermediaries are rewarded more than the actual water seller, who is usually a farmer in a peri-urban location.

**Water supply challenges in Chennai**

Chennai, the fourth-largest metropolitan city in India, is one of the rapidly urbanizing centres in South-Asia. The Chennai Metropolitan Area (CMA) comprises a total area of 1189 km2. It consists of Chennai City (176 km2), 16 Municipalities (240 km2), 20 Town Panchayats (156 km2), and 216 Village Panchayats (617 km2) (CMDA 2007).

Chennai witnessed rapid urbanization during the post-independence period, particularly during the post-liberalization period. The CMA’s population has increased from 1.5 million (1951) to 3.5 million (1971) to 5.8 million (1991) and further to 9.8 million during 2011. Besides the permanent residents, the number of migrants and floating population is also high in Chennai.

The provision of water for the ever growing urban population is a challenge to the city administration. Rapid urbanization, with the expansion of residential, industrial, and business establishments, has put significant pressure on the water sector of the city and its periphery. Chennai gets an average annual rainfall of 1290 mm. In the urban areas, only about 5% of the rainfall seeps into the ground.

Chennai’s water supply has a long history, dating back to when its first water supply scheme was provided in 1772 to the St. George Settlement
through the ‘Seven Wells Government Works’. 10 wells measuring around 5 meters were sunk in an area of about 5 kms north-west of the Fort, from where water was raised by manually operated devises, collected in a cistern, and distributed through cast iron pipes.

In 1866, a scheme called ‘the Madras Municipal City Water Works’ was approved to divert water from the Kosasthalaiyar River. A weir called the Tamaipakkam anicut was constructed across the river for diversion of its surface flows. Further, in 1944 a regulator was constructed across the river, 20 km upstream of the Tamaipakkam anicut to provide an assured supply.

In the 1960s, the irrigation rights of the command areas under Cholavaram and Red Hills reservoirs were purchased to fulfi... lives. 6 well fields were identified for groundwater extraction to augment the city’s demand.

The formation of the ‘Chennai Metropolitan Water supply and Sewerage Board’ (CMWSSB) as a statutory body in August 1978 is a landmark in the modern history of Chennai’s water supply. It was established to exclusively attend to the growing demand, and for the planned development and appropriate regulation of water supply and sewerage services in the Chennai Metropolitan Area, with particular reference to the protection of public health and all related matters. Several improvement works in the existing sources were taken up by the Board to provide an assured supply.

At present, surface water sources such as the reservoirs at Poondi, Cholavaram, Redhills, Chembarambakkam, Veeranam Lake, Rettaï Eri, Porur Lake, and Kandalur Reservoir in Andhra Pradesh under the Krishna Water supply Scheme, are the main sources of water supply for Chennai. Groundwater from the well fields developed in the Araniyar-Kosasthalaiyar River Basin, and the southern coastal aquifer and seawater-based reverse osmosis (desalination) plants are the other sources of water supply.

Even though a number of water supply schemes have been developed for the city, the Water Board is not able to supply an adequate quantity of water, particularly during periods of less rainfall. An analysis of the average annual rainfall in the surface water supply sources (Pondy, Cholavaram, and Redhills), and the water supplied to Chennai City over three decades, observed that the supply varies with respect to the rainfall. That is, when the rainfall was more, supply was high and vice-versa (Veeralakshmi 2009).

The volume of public water supply in Chennai progressed over time, but not very appreciably with respect to the population and economic growth. The decadal analysis of water supply revealed that even if the average water supplied has increased over the years, there is a considerable variation in the quantity supplied even in recent periods (Table 1). This is a clear indication of the insecurity in the Chennai water supply.

### Table 1. Quantity of water supplied to Chennai city
(Average per day in million litres)

<table>
<thead>
<tr>
<th>Years</th>
<th>Variation</th>
<th>Cumulative average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum</td>
<td>Minimum</td>
</tr>
<tr>
<td>1941 - 1950</td>
<td>110.99</td>
<td>79.48</td>
</tr>
<tr>
<td>1951 - 1960</td>
<td>143.84</td>
<td>66.90</td>
</tr>
<tr>
<td>1961 - 1970</td>
<td>178.53</td>
<td>120.61</td>
</tr>
<tr>
<td>1971 - 1980</td>
<td>243.11</td>
<td>114.94</td>
</tr>
<tr>
<td>1981 - 1990</td>
<td>256.74</td>
<td>140.50</td>
</tr>
<tr>
<td>1991 - 2000</td>
<td>410.50</td>
<td>112.22</td>
</tr>
<tr>
<td>2001 - 2010</td>
<td>586.55</td>
<td>140.40</td>
</tr>
</tbody>
</table>

Source: Computed, based on CMWSSB 2011 statistics
There are huge supply-demand gaps in the Chennai water supply, and the deficit during 2005-2008 ranges from 38 per cent to 58 per cent (Table 2). The deficit is primarily met through either extraction from the local aquifer or through transported groundwater from peri-urban areas. However, since the local aquifer is highly depleted and degraded, most of the deficit share might be mitigated through the groundwater market.

Changing the groundwater regime or emergence of the water market

Generally, most of the discussion on urban water supply focuses on the public water distribution system, in terms of per capita supply and its various related technical, managerial, and financial problems of its operation (Vaidyanathan 2007). However, the public system is not the only source of urban water supply, particularly in a water-scarce city like Chennai where different urban uses are affected by various private options. Historically, the groundwater extracted from privately owned wells was the main private source. That groundwater in the city has been depleting and degrading progressively, due to indiscriminate extractions and urban waste disposal. Hence, a considerable volume of groundwater has been transferred from peri-urban areas to the city.

The source-wise daily household water consumption in Chennai City (Table 3) indicates that public water (Metro water) supply contributes only less than one-third (31.6%) of the total consumption. Sources other than Metro water (which includes households’ own wells and bore wells, community wells, bottled water, Table 2. Water supply and demand status in Chennai City

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total requirement (Demand)</td>
<td>994.7</td>
<td>1014.6</td>
<td>1034.9</td>
<td>1055.6</td>
</tr>
<tr>
<td>Total supply</td>
<td>419.5</td>
<td>623.8</td>
<td>639.9</td>
<td>582.2</td>
</tr>
<tr>
<td>Deficit (%)</td>
<td>575.2</td>
<td>390.8</td>
<td>395.0</td>
<td>473.4</td>
</tr>
</tbody>
</table>

Source: Veeralakshmi 2009

Table 3. Source-wise daily household water consumption in Chennai City

<table>
<thead>
<tr>
<th>Source</th>
<th>Consumption (million litres)</th>
<th>Percentage share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metro in house</td>
<td>27.8</td>
<td>11.0</td>
</tr>
<tr>
<td>Metro outside house</td>
<td>52</td>
<td>20.6</td>
</tr>
<tr>
<td>Own wells/bore wells</td>
<td>123.3</td>
<td>42.7</td>
</tr>
<tr>
<td>Other / Community wells</td>
<td>28.3</td>
<td>11.2</td>
</tr>
<tr>
<td>Bottled water</td>
<td>3.9</td>
<td>1.5</td>
</tr>
<tr>
<td>Private tankers</td>
<td>20</td>
<td>7.9</td>
</tr>
<tr>
<td>Total</td>
<td>255.3</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Source: Vaidyanathan 2007
and private tankers) accounted for over two-thirds of the total domestic water consumption. Around 24 million litres of water for domestic households’ consumption is supplied by private tankers and packaged water companies, whose sources are the peri-urban aquifers. During surface water scarce periods, public supply also considerably depends on these peri-urban aquifers.

In other words, more than two-thirds of the total domestic consumption comes from groundwater, either within the city or from the peri-urban areas. Apart from households, private and public institutions, commercial establishments, and industries also demand a huge quantity of water. It seems likely that these would depend on private tankers to a greater extent than households.

Recently, considerable change has occurred in the groundwater regime. This is very clear from the nature of extraction within the city, and the increasing dependency on the peri-urban aquifer. In Chennai, from 1980 to 2004, the number of open wells had doubled, but the number of bore wells had increased nearly thirty-fold. A large number of shallow open wells have gone out of use with an increasing number of deep bore wells over the period. This is an indication of the lowering of the water table - a sure sign that the rate of extraction exceeds the rate of recharge, and that the static reserve (groundwater stock) is being depleted. The rate of extraction in a normal year (estimated at 180 mld) in fact exceeds the normal natural recharge estimated by CGWB (152 mld) (Vaidyanathan 2007).

Nowadays, tapping external sources of groundwater and water marketing (for public and private supply) is one of the major strategies to meet the growing city demand. During the 1960s and 80s three aquifers (Tamaraipakkam, Panjetty, and Minjur) in the north and north-west of the city, and those along the coastal belt from Thirvanmiyur to Kovalam were identified for city water supply. The north-east part of the city was taken up for extensive hydro-geological studies as part of a UNDP project, and established the potential for groundwater sources and development (Table 4). The table also clearly brings out the failure of wells due to the depletion of groundwater sources in the last 30 years, due to over-extraction of groundwater.

In addition to the above wells, the Water Board has hired private agricultural wells from early 2000 to augment the water supply. This practice was more during the scarcity periods. The average yield mobilized through these sources was 37 mld during 2001, but it increased to 77 mld by 2005 (CMDA 2008).

Availability of water and road accessibility are the main criteria in the selection of wells. More than 180 private agricultural wells have been identified, and from each well at least 10 to 18 loads of water were pumped (0.1 to 0.2 mld).

The price of water paid to the well owners varies with the season and quality of the groundwater. During peak seasons, the Metro Water Board transports at least 6000 tankers of water each day to the city. The total estimated cost of hiring these agricultural wells is Rs. 85 million per year (Janakarajan et al. 2007). In addition, numerous

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**Table 4. Well fields details**

<table>
<thead>
<tr>
<th>Name</th>
<th>Year commissioned</th>
<th>Initial period</th>
<th>2005</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Number of wells</td>
<td>Yield (mld)</td>
<td>Number of wells</td>
</tr>
<tr>
<td>Tamaraipakkam</td>
<td>1969</td>
<td>30</td>
<td>50</td>
<td>2</td>
</tr>
<tr>
<td>Panjetty</td>
<td>1969</td>
<td>13</td>
<td>41</td>
<td>1</td>
</tr>
<tr>
<td>Minjur</td>
<td>1969</td>
<td>9</td>
<td>34</td>
<td>5</td>
</tr>
<tr>
<td>Poondi</td>
<td>1987</td>
<td>12</td>
<td>27</td>
<td>4</td>
</tr>
<tr>
<td>Flood plains</td>
<td>1987</td>
<td>5</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>Kannigaipur</td>
<td>1987</td>
<td>5</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>74</td>
<td>180</td>
<td>12</td>
</tr>
</tbody>
</table>

*Source: CMDA 2008*
private tanker operators also transport water from various peri-urban villages, to supplement deficiencies in the public supply and/or to provide to users who do not have access to Metro water. In brief, acute water scarcity coupled with the ineffectiveness of government action has made the tanker water business a lucrative industry over a short span of time.

In the water market, three major parties are involved: water sellers, intermediaries (lorry tanker operators), and consumers. In the villages, some well owning farmers have been willing to involve themselves in the water market, because they can earn more by selling groundwater for urban use than from farming. The estimated net profit through the water market from a peri-urban well (selling an average of 10 loads per day at the rate of Rs. 100 per load) is Rs. 20,637 per month, which is far higher than the agricultural returns (Rs. 5000 per month) through irrigation from the same well. The selling price of water to urban consumers is around Rs. 700 / tanker with a 12,000 litre capacity. The lorry tankers’ net profit is Rs. 25,491 per month (Veeralakshmi 2009).

The inducement of water selling is especially strong during years of drought and lean seasons, when public supply will considerably reduce and private users are willing to pay relatively high prices. This tendency is growing because scarcity in the city is becoming endemic and increasing.

Apart from the tankers, the packaged water companies are also extracting a huge volume of groundwater from rural areas and transferring it to urban areas, where the majority of consumers are concentrated. According to such a company proprietor in Chennai, around 350 packaged water (water bottling) companies are in the Chennai area alone, while a majority of them are located in the peri-urban villages. The estimated groundwater transferred by 48 packaged water industries from peri-urban villages near South Chennai is 19.2 mld (Packyalakshmi et al. 2010).

Socio-economic implications of groundwater markets

Groundwater transport from Chennai’s peri-urban villages to the city is an inevitable practice that has been followed for nearly four decades. Unfortunately, most water marketing villages in peri-urban Chennai have been transferring groundwater without considering the overall human and environmental water needs in the villages.

Ideally, a market will transfer commodities/resources from surplus to deficit areas. In water markets, water selling farmers compare the values of water for crops or the agriculture sector to those of the urban demand. The prices set in the markets signal the marginal values of water for these different uses, and allocation takes place based on economic efficiency. However, the open access nature of the aquifer and the need for equitable accessibility of the groundwater for all local communities for their livelihoods are major social concerns. Besides, the ecological sustainability of the region is also significant.

In India, the rights to groundwater belong to the landowner as groundwater is attached with land. Since landownership is a prerequisite to ownership of groundwater, it is difficult to assign ‘open access’ to a groundwater resource. Though landowners own groundwater de jure, this right is limited by huge investment, necessary to tap the groundwater, which makes for only restricted access to those who have adequate resources to invest. Under these circumstances groundwater rights are obscure (Nagaraj 2009).

However, a deep bore well owned by a particular landowner can absorb the underground water that exists in its neighbourhood also, because an aquifer is interlinked, or not demarcated like surface land. According to the Planning Commission (2007), since groundwater is an open access resource, a ‘tragedy of commons’ often occurs when everyone tries to extracts as much water as he or she can and degrades the source in the bargain.

During the initial periods of water extraction, not one of the impacts (in the form of either groundwater depletion or degradation) was revealed in the peri-urban villages. Perhaps the extraction rate was below the recharge rate at that time, or within the limits of a sustainable yield. But over time, the extraction rate increased considerably, in proportion with the water requirements of the city. As a result, the groundwater table and the village economy have been affected in various degrees. For example, the estimated sustainable yield from the A. K. basin was 100 million cubic meters (Mm3) per year, but the total extraction was 300 Mm3, three times the sustainable yield (Janakarajan et al. 2007).

The emerging inferences and social implications of the water market in peri-urban Chennai are:

- In villages, rich farmers are mostly involved
in the water selling business, hence the ones making profits. They feel that water selling is more profitable than agriculture.

- The water market is a fluctuating and highly uncertain process. Hence, its magnitude and impacts vary from time to time, and place to place.

- Villagers insist that the extraction of groundwater for agriculture and local purposes is not the cause of depletion of the water table. According to them, through irrigation, a major share of the water recharges into the aquifer and stabilizes the hydro-geological system. They argue that selling or transferring has a much more significant impact on the aquifer.

- For the villagers, groundwater extraction and/or transfer for industrial purposes are more problematic than for domestic purposes, since it is viewed sympathetically.

- The depletion of the aquifer and water quality degradation have adversely affected the regional environment. Many water bodies have disappeared from the villages. The aquatic eco-system and biodiversity have also been affected because of it. In addition, in coastal belts, there has been extensive seawater intrusion.

- Most village activities (agriculture and livestock) have become less due to the trading of groundwater. The main victims are marginal farmers and agricultural labourers (the landless), who face severe unemployment problems. Many of them have migrated to the city to find employment, which puts extra pressure on the already stressed urban infrastructure.

- Drinking water scarcity and related problems are also acute in certain villages. Women face more problems on account of this water scarcity, because they have to fetch water from greater distances now.

There is no uniformity in the water market; its function and implications vary significantly. This is illustrated through four case studies. In the following a description is presented of each, outlining a different pattern of functioning and corresponding implications for water rights, access, reallocation, equity, and conflicts.

**Case 1: Benefits to Somangalam village**

Somangalam is a peri-urban village, located around 30 kms west from Chennai City. The Somangalam tank and its sophisticated irrigation network used to provide adequate water for agricultural activities. Moreover, the groundwater potential in the village was good. However, recently, agriculture in the village has reduced considerably, and most of the fields have not been cultivated. Farmers felt that agriculture was no more a profitable business.

In 2002, a water-scarce period in Chennai, almost the entire village was involved in the water selling business. Nearly all farmers sold an average of 20 tankers (12,000-13,000 litres) per day. Brokers facilitated the process by getting orders for water and making the necessary arrangements for water extraction from different locations in the village.

The entire village supplied water from irrigation wells with the help of irrigation pumping facilities, which was facilitated by the fact that electricity was free. According to villagers, ‘the Government itself ordered us to provide water to the city with the help of irrigation pumping systems.’ (Discussion with farmers 2008).

The selling price of water was Rs. 50 per tanker, meaning each farmer who was involved in the water supply business, earned Rs. 1000 per day or Rs. 30,000 per month. According to a farmer, ‘it was a golden opportunity for us since we never earned Rs. 30,000 per month through agriculture. We are still eagerly waiting for such opportunities.’ (Discussion with farmers 2008).

Villagers said that the water sold during 2002 did not affect either the groundwater table or the village eco-system. This might be because of the huge potential of water resources in the village as well as less utilization for agriculture in the recent past. Moreover, water transfer was not continued from Somangalam, except through two packaged water units, which extracted only a limited quantity of groundwater. There was a good groundwater potential in the village and extraction remained confined within certain limits.

**Case 2: Conflicts in Valliyur village**

But the situation is different in villages where water extraction is persistent. In these villages significant impacts were revealed and conflicts were also reported. Valliyur village is located 30 kms from the city, in the A.K basin of North
Chennai. Historically, groundwater was the primary source of irrigation and the main crops cultivated were paddy and groundnut. During the 1980s around 280 agriculture wells existed in the village at depths of around 50-80 feet. Due to water sales, the water table in the village has declined gradually and farmers have deepened their wells up to 130-160 feet. 60 dug wells have been abandoned due to a falling water table in 1990. 11 Metro Water Board bore wells supplying water to the city to the tune of 16 mld have mostly failed (9 out of 11). After this, the Water Board started to purchase water from the farmers in the village. In the initial period around 40 mld water was purchased from 75 farmers, while it reduced to 16.84 mld in 2004 due to the depletion of the groundwater.

Moreover, the Tamil Nadu Water Supply and Drainage Board also started to pump water for supplying Thiruvallur town from Valliyur village. Up to 1995, the people of Valliyur had been quite passive. That is, they did not resist water being transferred from the common lands of the village, though it had been happening for more than 30 years. But when the water table in the village started to decrease progressively, farmers had to spend a considerable amount of money to deepen their wells. Moreover, agriculture too had declined drastically, and this affected the livelihoods of the marginal farmers and agricultural labourers. Drinking water scarcity also became prominent in the village.

Resistance started to build up against the water extraction and marketing. Local Self Help Groups (SHG) started opposing the transport of water out of the village during 1995, and insisted to the village Panchayats to pass a resolution, banning water selling. But the Panchayat did not do it on the ground that ‘groundwater is pumped only from the Government land.’

When the purchase of water from farmers started in 2000, the village people again revolted. This time, too, the Panchayat refused to pass a resolution on the ground that ‘farmers are selling water from their own lands.’ Subsequently, some villagers filed court cases to ban water sale from the villages. However, the Metro Water Board succeeded in getting stay orders on these.

A violent conflict broke out on 15th August, 2004, when over 400 people gathered near the Metro Water pumping station. Metro Water and higher Revenue Department officials arrived on the spot. To stem the crisis a Peace Committee was formed. The committee consisted of members of water sellers, non-sellers, SHGs, and officials. The sale of water by farmers to the Metro Board was to be stopped according to the committee’s decision on 15th September 2004. But this decision did not materialize and water selling continued in the village. Metro Water argued that water purchase should not be stopped. Water sellers in the village also were keen on continuing to sell water.

On 16th September 2004, villagers gathered near the Metro Water Board’s giant water tank, from where water was pumped to the city. They blocked the road and broke the pipeline. After this incident, police arrested 44 people under the Public Property Damaging Act and remanded them to judicial custody for 15 days (Janakarajan et al. 2007). Even after all these problems and negotiations, water sales were resumed from Valliyur village!

Case 3: Environmental and socio-economic impacts in South Chennai villages

Eight peri-urban water marketing villages come under the Mambakkam mini-watershed in South Chennai. They were studied by Packialakshmi et al. (2010) to obtain a comprehensive view of the rural to urban water market. The quantity of groundwater transfer from these villages was 36.3 mld, of which about 17 mld was through private water tankers and about 19 mld as packaged water.

A groundwater analysis based on PWD data indicated a steep decline in the water table during 1971-2007. The pre-monsoon water table fluctuated more (2-7m below ground level, bgl) than the post-monsoon water table (0-3 m bgl). Earlier, this groundwater was available the whole year, but nowadays only for 3 months after the monsoon.

The water quality analysis revealed that the concentrations of TDS, chloride, and sulphate were high in certain villages, when compared to the BIS drinking water limit. The pre-monsoon and post-monsoon analyses revealed that precipitation and dilution were significant factors in the hydro-chemical constitution of groundwater. Hence, the pre-monsoon values of TDS, chloride, total hardness, and sulphate were slightly higher than those of the post-monsoon and BIS standards.

In other words, there was an inverse relationship between the water level and the concentration of the ions, i.e. an increase in the chemical...
composition of the water with a decrease in the water level (Pakyalakshmi & Ambujam 2011). It indicated that continuous functioning of a groundwater market in the villages may lead to further deterioration of the groundwater quality in the near future.

All water-marketed villages were experiencing a declining trend of agriculture. The reduction in area under cultivation varied from 28% to 93% in 1991-2007. Farming gradually has become a minor occupation, as urbanization has changed the land use pattern substantially.

This declining trend of agriculture has a direct relationship with proximity to the city, i.e. villages close to the city experienced a rigorous decline. The declining trend of agriculture forced people to move out from the villages in search of employment.

Villages are also experiencing severe domestic water scarcity problems. Since shallow wells dried up, many households had deepened their wells or dug new bore wells, but they were not satisfied with the yield. The water supplied through the public system was not adequate. Higher income groups in the village depended largely on packaged water.

The indiscriminate extraction and transfer of groundwater without considering its renewability adversely affects the village ecosystem, and sometimes an irreversible damage is caused to the aquifer. Earlier, the surface water potential in these villages was good, but now most of the water bodies are useless, due to their reduced base flow. Declining agriculture affects natural systems through a reduction in the return flow from the irrigation and run-off, and through water table depletion due to reduced recharge. Besides, it has also led to deterioration of groundwater quality.

When the public protested against the sale of water, government officials seized 11 tankers. Reacting to this, water tanker operators staged a protest, and more than 200 tankers were parked on the road at Medavakam, blocking the traffic (The Hindu 2010). However, the water market operating from the villages in the Mambakkam watershed is still active.

**Case 4: Sustainable and democratic approach in Kannapalayam village**

The water market experience from Kannapalayam is slightly different from the above cases, and unique because of its sustainable and democratic approach. Kannapalayam is a north-western peri-urban village of Chennai, located at the bank of the Cooum River in Poondamalli union, Tiruvalur district. In 2008, a water market started functioning from the village. Other than in the other water marketing villages, the Kannapalayam villagers decided that water from the agricultural wells or farm lands should not be sold, since it affected the water table and agriculture. Hence, they specified a location, adjacent to the Cooum. It is also the immediate downstream of a check dam constructed across the river during 2005, located far from farmlands and residential areas, exclusively available for water sale. Water sellers purchased small plots and constructed bore wells for the sale of water, and at present 8 wells are functioning.

Generally, in a water market set-up, the water supplying company (tankers) is located outside the village or cities. But in Kannapalayam, the villagers themselves are involved in the process, and they supply water to selected urban consumers on a regular basis. Outsiders are not allowed to enter the village for water. Presently around 50 villagers are actively involved in water transfer through their own tankers.

Mainly mini tankers (5500 litres capacity) are preferred in consideration of the poor road conditions in the village, and the distance of the supplying spot from the main road (4 kms away). Around 2.7 million litres of water (500 tankers) are supplied daily to the city from Kannapalayam. The average price of water taken by suppliers from wells is Rs. 60 per tanker, and the selling price is Rs. 850 (Focus Group Discussion 2011).

According to well owners and water suppliers, they had identified an excellent spot for water extraction thanks to its good yield and quality (sweet with less TDS), something that is naturally preferred by urban consumers.

Water is supplied to households and restaurants (not to industries), and the villagers felt that providing water for drinking is a great service. They also claimed they were actively involved in various social welfare activities in the village like supplementing the village’s drinking water supply, repairing motors free of cost, and giving donations for religious functions (Focus Group Discussion 2011).

However, village officials observed the water market from a different perspective, considering its long-term consequences. According to an official, ‘Even if the water market has many
advantages, it is a violation of the ‘Groundwater Act’ and hence illegal.

Initially, only limited quantities of water were transferred from the village, which they accepted on humanitarian grounds, since both villagers and consumers were benefiting. But now sales have increased considerably, and have become a real business with a profit motive. Some water selling wells had dried up recently; hence, new wells were constructed.

With financial and political influence, water sellers are overcoming various barriers in the water market. For example, to obtain an electricity connection from the Electricity Board (EB), the concerned applicant (bore well owners) was to get prior permission from the village authority by indicating the purpose. However, well owners have been obtaining such EB connections without this! On many occasions, the revenue authorities take action against the offenders by imposing fines, sealing the tankers, etc.’ (Personal interview with an official 2011).

Some villagers, who were not involved in the water market, also expressed their concern about draining the groundwater from the village by considering its depletion and degradation in future. However, they admitted that at present, since water extraction was restricted to an ideal geographical location, the overall groundwater table in the village was not affected (Discussions with farmers 2011).

**Need for sustainable groundwater water market**

Generally, population and economic growth, and the associated increase in water demand will place unprecedented pressure on aquifer systems. Further depletion and degradation of aquifers would be anticipated, unless there is much more investment in effective governance and management practices. In addition, climatic change will place some key aquifers under additional pressure. In heavily populated areas, communities will need to self-regulate resource use. Demand-side approaches that focus on obtaining a consensus on aquifer use may have more success in the long run than technical supply-side or hardware-led approaches (UNESCO 2009).

In many public debates, declining groundwater levels or quality are cited as the main reason for the need for management action, but resource depletion and degradation are only part of the problem. In the rural to urban water market, a proper evaluation of the groundwater potential, and monitoring and regulation of extraction from villages are essential. Precise data on the status of groundwater resources is still not available in sufficient detail to make a comprehensive assessment. In the Chennai case, we have noted that the rate of groundwater extraction within the city exceeds the natural rate of recharge.

According to the Groundwater Estimation Committee norms, the utilizable groundwater recharge in the Chennai river basins is around 1100 Mm3, and the current net groundwater draft 770 Mm3. On this basis there is a substantial unutilized balance available for exploitation. However, this is not consistent with the field observation of a progressive fall in the groundwater table in the eastern part of the basin, and the fact that out of the 26 blocks outside the city agglomeration (where groundwater is already over-extracted) only 3 are rated ‘safe’, 13 as ‘semi-critical’, and 10 are ‘critical or over-exploited’.

Hence, a reassessment of the groundwater potential, the current rates of extraction, the use for various purposes including water market, and the trends in the water table is necessary. A more up-to-date estimate of the agricultural use, and the likely reduction in it as the urban sprawl spreads up the basin, is also desirable to determine whether, in fact, the unexploited potential is as large as 350 Mm3 (Vaidyanathan 2007).

The rural to urban water markets are increasingly common adjacent to large urban areas as well as medium-sized towns, and their impacts are also more significant. In spite of this, the water market is an important institutional mechanism to manage water scarcity in urban areas.

The experience from many parts of the country reveals that there are no formal water markets functioning in India (Diwakara & Nagaraj 2003; Moench & Janakarajan 2002; Nelliyyil 2010; Nisha 2008; Veeralakshmi 2009). Generally, marketed water is sourced from groundwater. Hence, the issues related to water markets should be handled from a groundwater management perspective.

This study highlighted various issues involved in groundwater transfer from rural areas to cities. The state has attempted to address this issue legally. The Chennai Metropolitan Area Ground Water (Regulation) Act, 1987 ‘envisages the control, regulation, abstraction and
transportation of groundwater in the notified area through (1) the regulation of existing wells, (2) regulation of the sinking of new wells, (3) issue of licenses to extract water for non-domestic use, and (4) issue of licenses for transportation through goods vehicles.

In Chennai, the majority of the villages involved in water selling may be located outside the metropolitan area, and come under the Tamil Nadu Ground Water (Development and Management) Act. This act aims ‘to protect groundwater resources to provide safeguards against the hazards of its over-exploitation and to ensure its planned development and proper management in the state of Tamil Nadu and matters connected therewith or incidental thereto.’

Notwithstanding these acts, the over-exploitation of resources has taken place. Water trading may violate the conditions prescribed in the above mentioned acts. The concerned Government authorities are also not strictly enforcing the acts or taking any serious action whenever someone violates the norms.

A more convergent and sustainable groundwater resource management will be achieved only through: (a) substantial investment in management operations on the ground, (b) working primarily through community consultation, and (c) a cross-sectoral policy dialogue.

Groundwater recharge processes are extremely complex, and there is still considerable uncertainty about their relationship with natural vegetation, land management, and groundwater use. While many specific local-scale recharge studies are available, the knowledge of the range of recharge modes across large river basins and their linked aquifers rarely comes together to form a systemic overview. For many heavily exploited aquifers, groundwater abstraction and use are still poorly quantified, and dedicated groundwater monitoring networks have not been established.

Instead, periodic observations are made of pumped wells, which give only an approximate measure and are completely inadequate for detecting the response to recharge events. Many cities are working ‘blind’ when they distribute water supplied from groundwater sources. In some hydro-geologic settings it is difficult to improve on the efficiency of the natural recharge processes, while in others, the economically feasible proportion of recharge enhancement over natural recharge is very limited, although techniques can help solve local problems and improve groundwater quality.

The highest management priority, though, will always be to protect the main recharge zones. Historically, the tanks that exist in urban and peri-urban Chennai act as recharge structures. Unfortunately, at present most of the tanks have disappeared or shrunk due to unscientific urbanization and encroachments.

In brief, market forces, which treat water as a commodity, offer an effective way of reallocating limited water supplies among competing users. Both the rights of the use of water and the actual volume of water can be exchanged in the market or transactions within regions. No doubt, this will facilitate better allocation of scarce water resources across different sectors, so that the overall development objectives could be achieved at a much faster rate. However, since the rural to urban water market is informal, groundwater resources have experienced over-exploitation, which has led to substantial environmental and socio-economic impacts in rural areas. Hence, appropriate steps have to be taken urgently towards sustainable rural to urban water transfer.

Management strategies

According to Narain et al. (2014), while conventional approaches to urban planning and rural development create a dichotomy between rural and urban areas, the concept of peri-urban raises questions both about the sustainability and equity dimension of urban expansion. The groundwater depletion issues in peri-urban villages due to the emergence of water markets (supplying to cities) is a typical case.

Unfortunately, due to the hidden nature of groundwater controlled by hydro-geological features, not much scientific attention has been given to understand the dynamics of its flow in space and time. In most cases the rural to urban water transfer takes place informally, and the demand-driven exploitation without considering its regenerative capacity may lead to a crisis.

Easter et al. (1999) examined the effectiveness of the market in allocating scarce water resources, and found that informal markets may be good for local level allocation (traditional irrigation system), but formal markets will be required for transaction between different regions and sectors.
The aquifer depletion related problems are also an intra-generational issue. Even if various groundwater management Acts are enacted, they are unlikely to be effective. Since water is used for productive or ‘lifestyle’ purposes in urban areas, it is appropriate to apply economic criteria to its allocation. But water pricing alone will not produce the necessary reallocation, since prices in many sectors do not reflect the underlying economic values, and there are many cases of market or service failure (UNESCO 2009).

Reallocation from a lower to a higher value use can be achieved by enabling the traditional markets as well as by applying administrative measures, creating formal water markets or trading water rights. In any case, society and the concerned authorities should set appropriate limits on transfers to protect third parties, the environment, and wider social interests.

Groundwater management deals with a complex interaction between society, the hydro-geological (physical) environment, and policy designs. Aquifers are exploited by human decisions, and over-exploitation cannot be always defined in technical terms. Groundwater is a ‘common pool’ resource, and has been typically utilized in an ‘open access’ framework. Here, the users have no incentive to conserve the resources for the future, and their self-interest always leads to over-exploitation.

In the case of ground water, the establishment of some sort of water rights and a responsible system, specifying the withdrawal or entitlement of water, is crucial for the development and promotion of the water market in a much more formalized manner. Moreover, there are no institutional arrangements in place to: (a) govern water rights, (b) control the functioning of the informal water market, (c) effectuate pricing in the informal water market and (d) resolve conflicts. The introduction of a system of trading in water rights will provide opportunities for individuals who own water, to trade that property right to other potential users (Palanisamy 2008).

According to Shah, problems of groundwater over-exploitation in India are bound to become more acute and widespread in the years to come, unless corrective mechanisms are put in place before the problem becomes insolvable.

Lack of information and an absence of systematic monitoring of availability and withdrawal of groundwater are major barriers that prevent the transition from groundwater development to a management mode. Further, unlike in the case of surface water, public agencies have only an indirect role to play in the national groundwater sector, due to its development mostly in the private, ‘informal’ sector, and the quality and amount of application of science and management to this sector has been much less when compared to the surface water sector.

The present study clearly reveals the significance of groundwater for human needs and economic activities (urban requirement) as well as the consequences (rural activities), if the resource is over extracted. The challenge, therefore, is to supplement urban needs without affecting the village eco-system and economic activities. The groundwater extraction/transfer from villages should be within the limit of its regeneration. In this regard, the following suggestions are made:

- Proper mapping of the groundwater potential (both quantity and quality) in the water trading villages and estimates to be made of the aquifer regeneration level. This task may be carried out by the Groundwater Division of the State Public Works Department with the collaboration of the Central Ground Water Board. Since the agricultural water requirements are gradually going down in the peri-urban villages, a certain amount of water can be transferred to the city, keeping in mind the safe yield limits of the aquifer, and the ecological sustainability of the village.

- In the groundwater marketing villages, rainwater harvesting should be promoted. In this regard the concerned department should identify the appropriate spots for artificial recharge and build shafts. Moreover, natural recharge options such as tanks should also be activated through community participation.

- Since the Groundwater Acts are enacted in the State and the Chennai Metropolitan Areas, the norms specified in the acts should be strictly enforced in a way to regulate its over-extraction.

- Since the villagers are the cause and the victim of groundwater over-exploitation, proper co-ordination between them (water sellers and non-sellers) is required. In this, the local body (Panchayat) should take the lead in addressing the competing needs and ensuring village welfare.

- The Government should also think more about the economics of groundwater
management. Apart from fines, penalties, water cesses, or charges, the Government can also think of ‘compensation and incentive strategies’ for preserving groundwater.

• Since the water supplied through tankers does not undergo any treatment before consumption, the quality of the marketed water should be assessed to safeguard the health of the urban community, the ultimate consumers of the marketed water. The wells located close to polluting sources should not be used as sources for water selling.

Conclusion

The study highlights the critical importance of groundwater, and the need for its sustainable management with respect to the rural to urban water market. Precious and renewable natural resources like groundwater play a significant role, particularly during the years of less rainfall or surface water scarcity. In areas where surface water irrigation does not exist or insufficient, groundwater acts as a source of irrigation and its dependency is multiplied even after rural electrification. With ever-increasing demands from new domestic and industrial areas, groundwater has become an important source. However, this precious resource is under threat due to over-exploitation and pollution. Hence, the need for a judicious use and management of groundwater is essential for sustaining human livelihood and the ecosystem.

In Chennai, the absence of a perennial source as much as an inadequate and uncertain public water supply has induced people to depend on groundwater. But at present, most parts of the city face groundwater depletion and degradation. Moreover, the overall urban demand has increased manifold. Hence, a considerable amount of groundwater has been transferred from peri-urban areas. In Chennai’s case, since the water market also acts as a supplementary option for public supply failure or deficiency, it is a highly uncertain and fluctuating process. Therefore, its impact in villages is not consistent but varies considerably, based on many factors, as observed from the case studies. All case studies clearly reveal that the water market, which transfers groundwater from the peri-urban areas to Chennai City, acts as an effective demand management option. Since groundwater is a renewable resource, the magnitude of water transfer and the duration of the market play a major role in determining the stock of the resources. If the volume of extraction or transfer is within the regeneration capacity of the aquifer and the extraction durations are short (few days), its ecological impacts are insignificant, as Somangalam village experiences.

However, the continuous extraction of groundwater in huge quantities for water market adversely affects the aquifer in peri-urban areas. Its socio-economic consequences show up in peri-urban areas through a reduction in agriculture and drinking water scarcity. Besides, the water market adversely affects the quality of the groundwater. Since those people who are involved in the water market, are benefitting (at the cost of others), the water market has certain externalities associated with its functioning and conflicts have emerged. The results from the Valliyur village and the villages under the Mambakkam mini-watershed in South Chennai substantiate these arguments.

Even if regulatory measures are in place, on most occasions they are ineffective due to political pressure and lenient action from the government or enforcement agencies. The fact is that the groundwater in peri-urban areas is a critical source in meeting urban requirements. Further, undefined property rights of groundwater hamper the authorities in taking appropriate and strict actions.

The Kannapalayam experience indicated that a planned water market is helpful for a win-win situation for the peri-urban villagers (providers of groundwater) and the urban consumers (users of groundwater). The spot or locations identified as sources for the functioning of water markets and the selection of wells matter a great deal. The study proved that constructing the wells in the vicinity of perennial surface water sources (rivers, check-dams, tanks, etc.) with avoidance of wells located in agriculture and residential areas for a water market is an ideal strategy.

The study of the four villages in this paper suggests that rural-urban water transfers through water markets can create conditions for conflicts also. This usually depends on the nature of the aquifers, the level of exploitation, and the persistence of water extraction. Since groundwater is an invisible resource with a lack of clearly defined and enforceable property rights, conflicts can be common, though they may take long to surface.

Though well functioning rural-urban groundwater markets can play an important role in meeting the urban supply-demand gap, they have serious local equity implications as they
deprive local communities of access to this resource. Thus these markets represent a process in which some individuals or groups lose access to groundwater to support the needs of others. Hence, these markets need to be studied from a justice and equity perspective as well, other than being seen as a mechanism to reallocate resources from low to high value uses. There are emerging local voices of dissent, though they take time to surface. In the end, though, the persistence of these sales suggests that local politics and power relations may have a greater role to play in this process.

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