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Policing the Urban Pumping Race: Industrial Groundwater Overexploitation in Indonesia

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Summary. — This article examines the problem of urban groundwater mining in West Java, Indonesia. Groundwater tables in urban West Java have been sinking rapidly for two decades. Overpumping has driven up pumping costs while intruding salt or polluted water threatens groundwater quality. Industrial pumpers are mainly responsible for the increase in groundwater exploitation. Government efforts to regulate groundwater exploitation have so far lacked the street-level impact needed to stop the pumping race. Shifting the focus of monitoring and regulation from factory boreholes to factory waste-water outlets is discussed as a possible solution to the problem of limited administrative capacity. © 1997 Elsevier Science Ltd. All rights reserved

Key words — environment, groundwater, depletion, industry, Indonesia, Asia

1. INTRODUCTION

Asia's spectacular industrial growth has created a host of environmental problems: solid waste is randomly disposed of, emissions from factory smokestacks make the air unfit for breathing, industrial effluents pollute precious surface water, and overpumping causes groundwater levels to sink at alarming rates. Groundwater overexploitation in urban-industrial regions is one of the tough environmental issues facing Newly Industrializing Countries (NICs) and near-NICs. Throughout urban Asia factories, households, and public utilities are engaged in a free-for-all for dwindling groundwater resources, continuously deepening and adding wells to compensate for loss in pumpage, a vicious circle reinforced by continuing pollution of available surface water resources.

Throughout Asia, urban groundwater mining is seriously impairing groundwater availability and quality as well as causing disastrous side-effects. In Beijing (Smil, 1993, p. 43), Tianjin (Zhang and Niu 1995), Hanoi (Tung and Helm 1995), and many other cities, water tables have dropped tens of meters during the past decades leading to manifold increases in groundwater pumping costs. Overpumping has led to seawater intrusion in Jakarta (Soefner, Schmidt and Soekardi, 1987), Bangkok (Das Gupta, Paudyal and Seneviratne, 1987) and other coastal cities. In many cases polluted surface water seeps into the soil to replenish and so contaminate precious groundwater reservoirs. Heavy pumping of waterholding layers has also led to serious land subsidence problems. Many Chinese cities are affected by it (Smil, 1993, pp. 43–44), and parts of Bangkok are sinking at a rate of 10 cm. per annum causing great damage to roads and buildings and increased risk of flooding (Das Gupta, Paudyal and Seneviratne, 1987, p. G62).

Stopping Asia's urban pumping race is far from easy. Groundwater has a public good character. It is difficult and costly to exclude nonpayers from its consumption. Moreover, even though sinking water tables add to pumping costs, large-scale pumpers view resulting cost increases as marginal. Prices therefore inadequately reflect the diminishing availability of quality groundwater. If the market mechanism fails to curb groundwater withdrawals, so do management

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efforts by user groups. On the basis of a series of investigations of community self-management schemes, Elinor Ostrom predicted that user groups will be unable to bring resource use under control when the resource in question is large and amorphous, users large in number and unorganized, when users have problems monitoring one another's actions, and when communication between users is difficult (1989, p. 20). Urban groundwater reservoirs in Asia combine all the above-mentioned elements. Aquifers systems are large, groundwater pumping is difficult to monitor, users unorganized, there are hundreds of thousands of consumers, and their numbers increase swiftly.

Bringing in the government to regulate groundwater abstraction, finally, also has its problems. For one, Asian governments have only recently put environmental management on the policy agenda (Baker, 1989) where it competes for attention with a host of other pressing issues, among them industrial development. Increased industrial withdrawals are a main cause of the drawdown occurring in urban groundwater tables. Regulation of groundwater use therefore appears to be at crosspurposes with industrial growth. For another, many Asian governments lack the administrative capacity to regulate groundwater withdrawals. Effective groundwater regulation has two basic ingredients: an extensive network of observation wells and water meters for measuring how much water is being consumed and by whom; and an organizational structure capable of handling the diverse tasks of well installation and maintenance, water table monitoring, issuance of groundwater abstraction permits and quotas to thousands of consumers, groundwater tariff-setting, water meter installation, calibration and maintenance, meter-reading, and billing and collection. Many Asian administrations lack the capacity to perform such a complex set of tasks.

The problem of industrial groundwater mining prompts two questions. First, can Asian manufacturers cut back on their consumption of high-quality (ground)water without impairing their competitiveness? Put differently, are water conservation policies compatible with export-oriented industrial growth policies? Available evidence suggests that this is indeed possible. Regarding environmental regulation *in toto*, the experience of OECD countries does not indicate an adverse effect of environmental restrictions and the cost of abatement on manufacturing competitiveness (Jaffe *et al.*, 1995). As regards water conservation in particular, manufacturers in Israel, the United States, The Netherlands, Sweden, and elsewhere — prodded by water tariffs, effluent charges, abatement subsidies, and other incentives — have been able to cut back significantly on their consumption of quality water through changes in processing and cooling methods.[1] Overall, the OECD experience suggests that reduced industrial consumption does not automatically impair international competitiveness, as Asian manufacturers and their governments are likely to think.

Second, if groundwater conservation does not necessarily entail a loss in export competitiveness, how can Asian administrations use their often limited regulatory capacity to promote industrial groundwater conservation? This article uses a country case, that of groundwater management in the Indonesian industrial heartland of West Java province, to investigate the administrative room for maneuver and policy options available to Asian policy makers.[2] It describes the causes of the urban pumping race; investigates why the Indonesian government has so far allowed industrial pumpers to overexploit urban aquifers; discusses an alternative framework for urban groundwater management based on joint regulation and monitoring of factory borehole and waste-pipe; and draws out important lessons from the Indonesian experience.

2. URBANIZATION, INDUSTRIALIZATION AND GROUNDWATER USE

Two general causes underlie the problem of urban groundwater overconsumption: concentrated industrial and population growth and the finite resource characteristics of water stored in subterranean layers. Like most other Asian countries, Indonesia has urbanized rapidly, its proportion of city dwellers increasing from 14.6 to 30.9% during 1960–90. Indonesia has three major metropolises: the capital Jakarta, Bandung in West Java province, and Surabaya in East Java province. Manufacturing activities are heavily concentrated in and around these urban nodes.[3]

A double-digit expansion in real industrial output has been recorded for Indonesia nearly every year since 1970. The lion's share of industrial growth has accrued to West Java. During 1974–91 West Java's officially recorded industrial workforce increased eightfold to 987,000 workers, the number of factory establishments growing from 1,600 to over 4,400.[4]

West Java's industries consume large quantities of water. The textile and leather industries, for example, labor-intensive industries traditionally associated with developing country comparative advantage, require huge quantities of clean water in certain phases (dyeing and tanning) of their respective processing cycles. As pollution of surface water has intensified, factories have increasingly relied on groundwater for processing and cooling.

Estimates available for one industrial region, the Bandung basin, indicate that in 1990 manufacturing firms were responsible for half of all groundwater pumped. Figure 1 traces groundwater abstractions in the latter industrial zone from wells deeper than 50 m over the course of the century. As Figure 1 shows, groundwater consumption has increased concomitantly with the manufacturing-led economic expansion of the basin that began in the early 1970s. Table 1 shows that manufacturers are mainly to blame for the basin's groundwater overdraft problem: industrial pumpers were responsible for 60% of the increase in groundwater withdrawals during 1950–90, their share in total groundwater abstractions growing from 18 to 53% in this period.

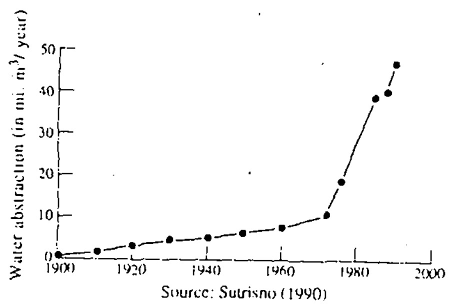


Figure 1. *Groundwater abstraction (well +50 m), Bandung Basin 1900–90.*

3. A CASE: THE BANDUNG BASIN

The well-documented case of the Bandung industrial zone illustrates these developments. The zone is located on a highland plateau 40 km long and 15 km wide in the central part of West Java province at an altitude of about 700m. The plateau is surrounded by steep mountain ranges that reach up to over 2,000m. The catchment area of basin and surrounding mountains covers 2,300 km² and encompasses three administrative units. Bandung municipality, an urban area 81 km² in size perched against the Northern mountain range, the surrounding Bandung regency, plus part of Sumedang regency.

Bandung's population increased from less than 40,000 in 1906 to nearly one million in 1961 and had expanded to two million in 1990, with average population density in the municipal area 25,000 persons/km². In addition, a significant spill-over of growth into the surrounding Bandung regency took place, the population of which doubled during 1961–90. In all, over five million persons inhabited the basin in 1990.[5]

Expansion of manufacturing industry has depended on and in its turn stimulated urbanization. The Bandung basin is a long-time producer of textiles and agro-products and was swept along in the extremely rapid industrial expansion of the 1970s and 1980s (Braadbaart 1992, 1994). In 1986, over one-third of the officially registered working population, nearly 234,000 persons, were reportedly employed in over 25,000 manufacturing enterprises (Sensus Ekonomi, 1986).

(a) *Geohydrology of the Bandung basin*

A complex layered structure of aquifers underlies the Bandung basin, groundwater availability and flows being determined by the basin's geological history.[6] The presently tapped aquifers stretch down to a depth of up to 250 m below the surface, lying on top of deep tertiary layers of marine sediments, old volcanic deposits and rock formations. The young top layer was deposited in the pleistocene and holocene eras by the volcanoes surrounding the central plain. In the pleistocene, a huge *lahar* flow from the Tangkuban Prahu volcano dammed the central basin, which then became inundated for a long period.

Bandung city lies close to the South of the Tangkuban Prahu, perched on top of its lava deposits. Lithologically, this lava fan is composed of breccia, lava and tuffs. Aquifers have formed where clay and silt were washed out of the tuff layers and sandy tuff or sand remained behind. Tuff layers with higher silt and clay content form aquitards, layers of deposits with low water permeability. The geology of the basin is

Table 1. *Estimated groundwater abstraction by well type and user category, Bandung basin, 1950 and 1990*

Well type	User category	Abstraction in m³/second 1950	1990
Shallow wells	households	0.4	1.1
Deep wells	industry	0.1	1.8
(>30 m)	public utilities	0.0	0.5
Total abstraction		0.5	3.4

Source: IWACO (1991).

marked by strong spatial variation but a simplified image of the groundwater system underlying the industrial zone is that of three aquifer systems lying on top of one another separated by aquitards. The deepest aquifer system reaches downward from 100 m below the surface. An intermediate aquifer system stretches from roughly 40 to 100 m below the surface. Shallow aquifers reach down to a depth of about 40 m below the surface.

Water flows underground at varying speed, through cracks and fissures in solid rock or between granules through sandy tuff formations. The aquifers are replenished by abundant seasonal rainfall, varying between 1,700 mm per year in the central part of the basin and 3,500 mm/year in the surrounding mountains. Both surface water and groundwater flows downward from the watershed zones to the central basin on the plateau, emptying in the Citarum river. Part of the rain falling in the watershed zones penetrates the earth and becomes part of the shallow aquifers. Half of this infiltrated water does not reach the intermediate and deep aquifers in the basin but is lost through evapotranspiration and via springs, wells and rivers. According to the best available estimates the aquifer system in the basin is recharged annually with 80 million m^3 of water (2.5 m^3/s).

This abundant supply notwithstanding, water has become a scarce resource in the Bandung basin. In part, this scarcity is due to natural causes, precipitation being both a seasonal phenomenon and a highly variable occurrence. A substantial amount of rain falling in spectacular tropical thunderstorms is lost through evaporation and run-off. The main cause of water scarcity, however, is limited water management capacity in conjunction with a number of negative side-effects of urbanization. Mountain flanks are progressively denuded as farmers clear more forest to make room for the profitable cultivation of horticultural products. The capacity of the Northern mountain range to retain precipitation steadily declines as houses reaching upward from the city encroach on forest areas. Finally, surface water reservoirs are contaminated by household sewage and industrial wastewater (Braadbaart, 1995).

(b) *Groundwater withdrawals*

The two primary categories of groundwater withdrawers in the basin are shallow well pumpers and deep well pumpers. The majority of shallow wells is used for domestic purposes. Half of the households of Bandung city depend on private wells for part or all of their water supply (IWACO, 1991). Shallow wells usually reach no deeper than 20 meters and water is lifted with buckets, handpumps or small electric waterpumps. Deep wells are operated by the regional water company or by private firms such as manufacturing companies and hotels. Submersible pumps draw water from boreholes that are more than 40 meters deep and in some cases over 200 meters deep.

The first deep well was drilled in Bandung city as early as 1893. At this time groundwater was tapped in order to secure a year-round water supply. After the 1940s, surface water pollution forced inhabitants to rely increasingly on groundwater. The second half of the 1970s saw a strong increase in the number of permits issued for deep wells. The number of permitholders leapt from only 96 in 1972 to 300 in 1976, increased to 686 in 1985 and stood at 971 in 1990. Nearly all new applicants were manufacturing enterprises, manufacturers thus taking the lead in groundwater withdrawal.

The sixfold increase in groundwater abstraction during 1950–90 (see Table 1) has had a disastrous impact on groundwater availability and quality. In the late 1970s the point was reached where the amount of groundwater extracted began to exceed natural recharge rates. Monitoring wells indicated water tables falling at alarming rates. The following quote from a 1978 review of planning issues shows that urban planners were well aware of the impending calamity.

> The uncontrolled groundwater development by major private consumers has progressively reallocated water resources to the detriment of other sectors. Dug wells used for modest domestic supply have fallen dry in an entire quarter of the city due to the spreading drawdown cone of industrial wellfields, and the yield of artesian wells which formerly directly fed part of the urban distribution system in Bandung and Cimahi has declined or failed completely. Expenses are incurred because wells had to be deepened or reconstructed and growing pumping lifts consume more energy (each metre of added drawdown will increase the overall cost of pumping in the Bandung area by about 2%. In some locations the drawdown has reached 20 m up to now). The quality of groundwater is affected by induced influent seepage from polluted surface water courses. Groundwater of lesser quality from the shallow aquifers invades the deep aquifers from which formerly good and unobjectionable water was readily obtained. For certain industrial purposes therefore treatment of the process water (has become) necessary (Riemer and Rozestraten, 1978, p. 24).

Increased pumping led to a rapid sinking of water tables on the plain. During the 1980s, the average annual drop in water tables in the basin was one meter. In the most heavily pumped areas annual drops of up to 2.5 meters were recorded (Sutrisno, 1991, p. 9). Consequently, well productivity plummeted. Even though pumping capacity was increased, the output of wells operated by the regional drinking water company (PDAM) in the basin decreased markedly. In 1983, production still amounted to 14.5 million m^3. By 1988 less than 8 million m^3 was pumped (Sukrisno

and Suyono, 1990, p. 26). Pumping costs also increased significantly. In 1980, one pump installed at 10 to 20 m below surface level still sufficed to produce 10 l/s in Dayeuhkolot, a core industrial area in Bandung city. Eight years later four pumps installed at 90 m were required to draw the same amount of water. According to one estimate this drove up real pumping costs by 250%, from 77.2 Rp/m^3 in 1980 to 199.3 Rp/m^3 in 1988.[7]

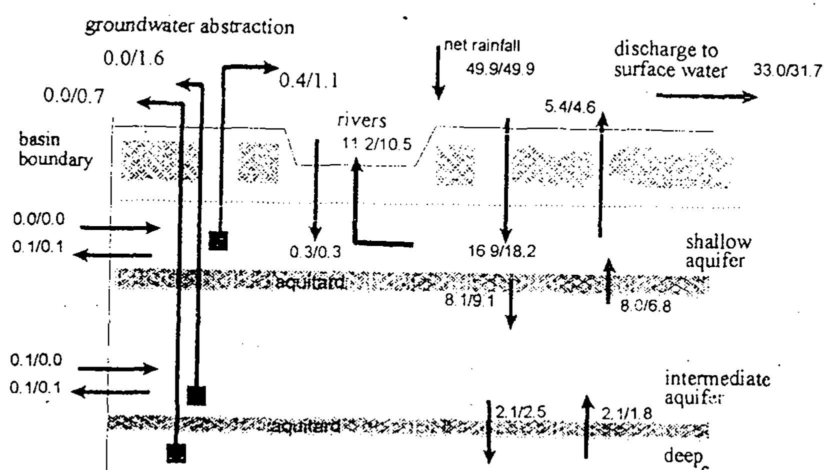
Increased pumping also led to drastic changes in the time and direction of travel of water underground. Figure 2, constructed on basis of monitoring well data, shows how increased pumping has affected the groundwater balance in the basin. Arrows indicate water flows, accompanying pairs of numbers their estimated magnitude with left-hand numbers indicating 1950 flow estimates and right-hand numbers 1990 flows. Comparison of the number pairs shows that increased pumping of aquifers has created a new equilibrium, with an increasing volume of polluted surface water seeping into the ground to redress the water balance.

Whereas formerly rainwater falling on the mountain flanks tended to seep slowly into the deeper aquifers to resurface on the central plain after thousands of years, now rainwater falling on the central plain infiltrates the ground, where it recharges the deep aquifers, and resurfaces after only 10–25 years. This short cycle has a negative effect on groundwater quality. Old supplies of high-quality fossil groundwater are rapidly being used up, and shallow groundwater resources are contaminated by polluted surface water infiltrating in the central part of basin. Water drawn from nearly all shallow wells is now contaminated by fecal coliform (IWACO, 1991).

4. THE FLAWED REGULATORY FRAMEWORK OF GROUNDWATER MANAGEMENT

Why has the Indonesian government failed to put a halt to the urban pumping race? The problem is not that no groundwater management policy exists: A regulatory framework has been in place since the early 1980s. Rather, the problem lies in weak enforcement. Indonesian groundwater management policy rests on two instruments: water quotas and water tariffs. In theory, these instruments should promote water conservation among industrial users. In practice, perfunctory enforcement has rendered them ineffective.

Table 2 provides information on large-scale industrial and commercial water abstractions in West Java as registered by the provincial government in 1993. The data indicate that firms did not possess the mandatory abstraction license for two out of every three registered water intake points. Moreover, three out of every five pumpers did not meter abstractions as prescribed by the law. Rather than paying the m^3 tariff meter-less pumpers paid Revenue Agency meter readers a negotiable lump sum the size of which, according to revenue collectors, bore little relationship to actual withdrawals. Finally, as will be seen, industrial pumpers did not pay at all for a substantial amount of water pumped from unreported boreholes.



Source: IWACO (1991)

Figure 2. *Bandung Basin water balance 1950–90 (all units in m^3/second).*

Table 2. *Registered water abstractions, West Java Province, March 1993**

		Bandung basin	Jakarta surrounds†	West Java total
1.	Number of permitholders	1,310	1,285	4,210
2.	Total registered annual withdrawals (in million m³)	77.4	70.7	255.1
3.	Number of reported abstraction points	1,719	1,622	5,132
	(a) points with license	692	776	1,709
	(b) points without license	1,027	846	3,432
4.	Percentage of permitholders metering abstractions	56%	56%	39%

*Available data do not differentiate between surface water and groundwater abstractions, licensed surface water abstractions comprise only a minor share in the figures presented.
†Bogor, Tangerang and Bekasi regencies.
Source: Primary data.

(a) *Why groundwater quotas remain unenforced*

The following public agencies populate the arena of groundwater management in West Java. The Environmental Geology Directorate (EGD) resides under the Directorate General of Geology and Mineral Resources which is part of the Department of Mines and Energy. The Department of Mines and Energy has formal jurisdiction over groundwater. Its operational arm, the EGD, monitors groundwater resources and provides technical advice on groundwater use. To this end it employed a small monitoring unit (comprising of about 20 personnel) responsible for all groundwater on Java. A member of this unit estimated that the larger groundwater-using factories were inspected approximately once a year. In addition, the team had installed a small number of monitoring wells in and around main urban centers and checked in case of complaints about groundwater.

The EGD exercised regulatory power over groundwater use through a "binding technical recommendation" (Puspowardoyo, 1986, App. II/13) attached to every new deep well permit issued. The recommendation stipulates the quota, that is, the maximum amount of groundwater that may be abstracted. The EGD, however, had no formal power to enforce this binding recommendation, the reason being that it shared its groundwater management task with the West Java provincial administration. The issuance of deep well mining permits was the Governor's mandate, not that of the EGD.

This overlap of jurisdictionary authority was a product of Dutch colonial rule. From 1884 onward, private firms were allowed to drill wells deeper than 15 m with permission of the Governor General. In 1912, the Mining Bureau, forerunner of the present-day Department of Mines and Energy, was made responsible for groundwater management and the issuance of deep well drilling permits to private operators. Twelve years later, however, this structure was overturned and the current arrangement introduced with the apportioning of concessional authority to the provincial administration. The Department of Mines and Energy was granted what was officially described as a "consultatory" function (Puspowardoyo, 1986, p. 4).

In the 1980s it was this division of labor between the Department of Mines and Energy and the provincial administration which led to government failure in groundwater quota enforcement. West Java's provincial administration operated through two agencies. The first agency was the Water Management Office. This office handled the administrative part of groundwater permit issuance: it consulted the EGD on quota recommendations, took care of the necessary paperwork, handed out groundwater use permits with a list of "do's and don'ts" to industrial pumpers, and was also responsible for the biannual reregistration of permitholders.

The second agency involved in groundwater management was the provincial Revenue Agency. The Revenue Agency was responsible for the collection of water retributions. Groundwater permit holders were required to install a water meter which was to be checked by Revenue Agency meter readers at regular intervals.

Figure 3, which offers a blueprint of the regulatory framework, shows why things went wrong. First, the EGD was responsible for groundwater conservation but lacked the regulatory power to enforce the quotas it prescribed. When permit holders pumped more than the amount set by the EGD, the latter could not act by revoking a water extraction permit.

Second, the Water Management Agency saw itself as an administrative clearing-house, not as an environmental law enforcer. Water Management Agency officers did not have much choice in this respect as they were literally tied to their desks. The Agency did not have an operational budget and therefore was

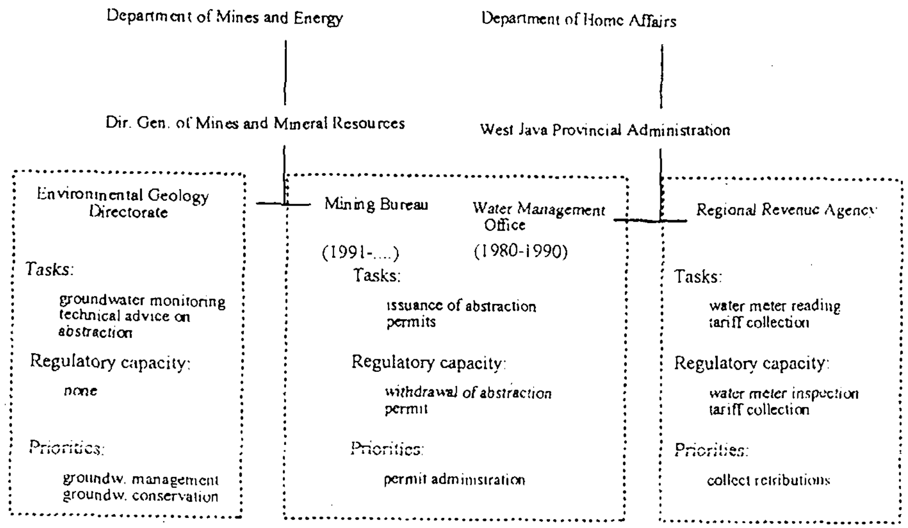


Figure 3. *Groundwater management in West Java: Allocation of tasks, capacities and priorities.*

unable to organize field expeditions and find out which firms pumped in excess of their quotas. This explains why it never used its regulatory clout (withdrawal of groundwater pumping permits) against noncompliant firms.

Third, the Revenue Agency was the sole agency in this set-up with both the regulatory power and the necessary freedom of movement to act against overpumpers. Unfortunately, groundwater conservation clashed with the Revenue Agency's core priority, that of raising provincial revenue. Perversely, it was in the interest of the Revenue Agency that groundwater users consumed as much water as possible, since more groundwater consumption implied more provincial revenues. The upshot of this regulatory arrangement was that permitholders were allowed to extract unlimited amounts of water from their wells.

(b) *Price incentives: groundwater tariffs*

Groundwater pricing policies also failed to stimulate industrial water conservation, the reason being that the cost of groundwater (tariffs plus pumping costs) was insufficient to affect the decisions of industrial pumpers. The impact of the tariff was blunted by the fact that industrial and commercial users paid only for about half of the groundwater they pumped.

A groundwater tariff regime was established in West Java in 1982. Tariffs were raised in 1988, 1990

Table 3. *Groundwater tariffs, West Java Province, 1992 (in Rp.)**

(Sub)sector	Groundwater abstracted (in m³ per month)				
	0–100	101–500	501–1,000	1,001–2,500	2,501+
Agriculture	50	60	70	80	100
Tourism	50	70	100	150	200
Trade + Services	50	70	100	120	150
Drinking Water Company	90	150	180	225	300
Home industry	0	30	30	30	30
Other industry	60	100	120	150	200

*US$1 = Rp. 2,000.
Source: Primary data.

and 1992. Table 3 reproduces the 1992 schedule. As may be seen groundwater rate-making reflects the long-standing Indonesian tradition of providing public goods at subsidized prices to agriculturalists and small industrial entrepreneurs. By contrast the state-owned Drinking Water Company paid a tariff higher even than that of the large private consumers.

The tariff price range for medium and large manufacturers was set at Rp 20–60/m³ ($0.01–0.03 at current exchange rates) in 1988, increased to Rp 40–100 ($0.02–0.05) in 1990, and was raised to Rp 60–200 ($0.03–0.10) in 1992. Industrial users however, did not pay for a substantial amount of the groundwater they pumped. Groundwater abstraction data for the Bandung basin allow an estimate of groundwater tariff evasion. According to the figures quoted in Table 1, real industrial consumption of groundwater amounted to 57 million m³/year in 1990. Assuming no water lost in distribution and an average groundwater tariff of Rp 150/m³, revenue should have been on the order of Rp 8.5 billion in 1991–92.[8] The actual amount of revenue collected in the basin was only Rp 4.6 billion, however. This would imply that only 54% of potential revenue was collected. In other words, industrial pumpers acquired half of their groundwater at pumping cost only.

5. COST OF GROUNDWATER TO INDUSTRIAL CONSUMERS

How does all of this translate into financial administration and decision making in Indonesian factories? Available evidence on this issue is impressionistic. Our own efforts at data collection yielded few results as factory managers approached by us were either unwilling to disclose (sensitive) financial details or unable to provide water production cost data, these being recorded incompletely or not at all.

A 1991 World Bank mission inspected eight textile dyeing mills and found an average water use per plant of 47,000 m³/month. Assuming a pumping cost (operation, maintenance and write-off of wells included) in 1992 of 300 Rp/m³, a Rp 200 tariff and a 50% "theft ratio," these factories paid Rp 300 + (200/2) = Rp 400/m³ ($0.20) for their groundwater. Applying this cost figure to the sampled firms shows an average expenditure of just under $10,000 on water tariffs per month within a range of $1,000 to $15,000.[9] The study cited provides no data on production costs and profits, but drawing on our experience we estimate that the former varied, depending on firm size, between several hundred thousand and several million US$ per month. If these estimates are correct, the dyeing mills spent only a tiny fraction, about 1–2%, of their budgets on water.

Because pumping costs were only partly accounted for in financial administration — company calculations of the cost of groundwater often did not seem to include maintenance and depreciation — in reality the cost of water probably figured even smaller in company accounts. A large denim-exporting textile mill we visited, for example, calculated that it paid less than $2,000 for its groundwater on a monthly basis, a minute fraction — less than 1/20th of 1% — of its monthly production budget of $4 million.

Overall, this fragmentary evidence suggests that the perceived cost of groundwater to industrial consumers in West Java was too low to provide a financial incentive for groundwater conservation. The underlying causes were partly low real price and partly rudimentary accounting practice.

6. IMPACT OF INCREASED FIELD MONITORING ON TARIFF COLLECTION

The first half of the 1990s saw positive change in the effectiveness of groundwater administration in West Java. This was wholly due to a single measure, namely the transfer in June 1991 of groundwater permit administering from the West Java provincial administration to the West Java Mining Bureau of the Department of Mines and Energy (refer to Figure 3). This transfer was not motivated by a desire to improve the effectiveness of groundwater management, but was part of an unrelated reorganization of the West Java provincial administration. Albeit a chance occurrence, this led to a marked increase in water tariff collection.

As recounted above, the provincial Revenue Agency was the key player in groundwater enforcement. The Revenue Agency had a routine budget for field inspections and collected groundwater tariffs for the provincial treasury. The Revenue Agency was, however, uninterested in groundwater conservation. When it organized field excursions it did so to apply pressure on permitholders who were in arrears with their water tariff payments, not for hunting illegal pumpers. But whereas its former provincial counterpart, the Water Management Agency, had been a passive "paper-moving" unit, the newly appointed Mining Bureau actively pursued a policy of groundwater law enforcement. The latter not only accepted invitations to join in the Revenue Agency's regular field excursions, it also proposed additional surprise field inspections ("*Aksi Mendadak*," abbreviated to SIDAK) to the provincial administration, specifically aiming to increase compliance with groundwater law.

Three such SIDAK operations were approved and carried out in 1992 in the Bandung basin, and eight more in the following two years focusing on the other major problem area, the Jakarta industrial region. The SIDAK excursions were funded from development rather than routine provincial budgets. Each lasted two weeks and fielded about 12 officials divided in

three mobile units. The cost of one SIDAK operation amounted to about $11,000, manhours, cost of transport, and overheads included. The impact of these "curbing operations" — as they were referred to by Mining Bureau officials — on revenue collection was striking. West Java annual revenues from industrial/commercial surface and groundwater levies jumped from $2.8 million in 1991–92 to $4.5 million in 1992–93 and grew to $6 million in 1993–94, that is, revenue increased by 114% over this two-year period.

Summing up, the administrative reshuffling of West Java groundwater management in 1991 created leeway for the Department of Mines and Energy to pursue its groundwater management mandate. The Mining Agency lobbied successfully with the provincial administration for field campaigns aiming at increasing compliance of industry with groundwater tariff regulations. A relatively small investment made in field inspections — about $120,000 was spent in 11 field campaigns — in 1992–94 led to an increase of several million dollars in groundwater tariffs collected.

7. REGULATORY COSTS AND BENEFITS OF BOREHOLE AND END-OF-PIPE METERING

The foregoing discussion of Indonesian groundwater conservation policies bears out that limited administrative capacity is a key constraint in environmental management. It is important then to look at the implementability of different regimes of groundwater use management. One regulatory option would be the erection of tariff-and-quota regimes around groundwater drawn from boreholes. Such a borehole-focused system is relatively costly and difficult to administer, however.

First, illicit pumping is relatively easy. A borehole, once installed, is unobtrusive and easy to hide. Tracking down illicit pumpers indirectly from the drawdown troughs created by their pumps is also well nigh impossible as this would require a very dense network of observation wells.[10]

A second problem with borehole metering is that of obtaining accurate information on water volumes withdrawn. To date no water metering method exists that is at the same time reasonably accurate, maintenance-free, affordable, and tamper-proof. Inexpensive rotary vane water meters of the kind used in public water supply may seem the obvious solution, but their accuracy depends on a host of environmental factors: water containing iron and suspended solids cause corrosion and clogging problems, undersupply of water affects their accuracy, discontinuous supply impairs their performance, and so on.[11] In order to be effective, a water metering regime based on this technology must therefore encompass detailed rules on the type and quality of meters to be installed, meter installation procedures, maintenance routines, recalibration and replacement intervals, etc.

A highly appropriate — simple, robust, inexpensive and capable of coping with varying water quality and borehole yield — metering alternative to the rotary vane meter involves collecting pumped water in a reservoir and timing its inflow or outflow.[12] But this technology offers snapshot views of water volume pumped only.

These technical complications create a situation where accuracy of borehole yield data reported must be checked on-site by regulators. This, to turn to the third problem, is a sore point in many Asian countries. Lack of access to meters located on factory premises is an important obstacle to effective regulation. Regulators and private industry interact in an atmosphere of avoidance, distrust and hostility, particularly in those Southeast Asian countries where overseas Chinese dominate the private sector. Most Indonesian factories, for example, have the appearance of well-guarded fortresses; street-level administrators rarely venture past the guard and inside the factory compound; factory management is normally given prior notice of an inspection visit, which then lacks the important element of surprise; and visiting regulators are often restricted in their movements.

In view of these problems there are various advantages to an end-of-pipe metering system. First, it is more difficult to dispose of waste-water without being detected than to pump groundwater from an inconspicuous borehole. An additional regulatory benefit is that because effluent disposal can be visually monitored, concerned outsiders (residents living close to factory complexes, environmental nongovernment organizations) can actively participate in enforcement.

Second, access to the factory grounds is not strictly necessary for on-the-spot checks of waste-water as waste pipes and channels must exit from the premises in order to discharge on surface water. The problems of accurate metering may be comparable to that of pumped water, but regulators can at least avoid the problem of gaining entry to the factory premises and are free to conduct surprise checks on protruding waste-water pipes.

Third, various Asian countries, Indonesia included, have already invested in waste-water quality monitoring and regulation.[13] Recording waste-water quantity along with quality would require only minor adaptations to this apparatus, thus enabling one to kill two birds with one stone. It would be relatively easy to augment the waste-water quality standards systems already used in many countries with a waste-water tariff regime.[14] Fourth, an effluent tariff has the psychological advantage of encouraging re-use.

The main drawback of end-of-pipe metering appears to be that water en route from borehole to waste pipe may infiltrate the soil through intentional reinjection into the ground and via unintended seepage of water from reservoirs, pipes and leaking taps. Intentional reinjection does not seem to present a real danger as manufacturers would then be polluting vital groundwater resources directly underneath their factories. It seems sensible, however, to use end-of-pipe metering in conjunction with borehole metering. This offers regulators two measuring points and marked disparities between reported abstractions and reported emissions as telltale signals of illegal water withdrawals.

8. CONCLUSIONS

This article has discussed the Asia-wide problem of groundwater overexploitation in urban-industrial areas. Recent Indonesian attempts to promote groundwater conservation in urban West Java indicate that effective intervention, given limited local capacity to enforce regulations, is of paramount importance. Industrial and commercial pumpers are mainly to blame for the disastrous increase in groundwater pumping occurring after 1970. A well-designed legislative framework for groundwater conservation was put in place in the early 1980s and a groundwater tariff-and-quota system introduced to limit and discourage industrial pumping. But this did not put a halt to urban groundwater mining. Private firms evaded tariffs and quotas on a large scale. They failed to report boreholes, did not install required water meters, and withdrew large quantities of groundwater without paying the tariff. Apart from the evasion problem, the tariff instrument probably also lacked impact because tariffs were set at levels too low to affect decisions of industrial pumpers.

The above signals serious enforcement problems on the part of the Indonesian administration. The implementation of the tariff-and-quota system went askew because tariffs collected disappeared in the provincial treasury rather than being used for environmental management. Not only was the agency in charge of groundwater conservation, lacking a revenue base, thus financially handicapped, it also missed the legislative power to take action against evaders. The task of quota enforcement, meter reading, and tariff collection was entrusted to an agency responsible for collection of provincial revenues. This agency experienced a conflict between its main mission of collecting levies and that of promoting groundwater conservation as a result of which pumpers were allowed to withdraw unlimited quantities of groundwater.

The counterproductiveness of this arrangement came to light when administrative powers were shifted from the provincial administration to the groundwater conservation agency. The latter pushed for intensified field monitoring which in turn led to a marked increase in groundwater tariff revenues. This signifies that the organization of the implementatory side of environmental management needs careful attention.

Finally, administrative problems were compounded by the fact that field administrators had difficulty in communicating with industrial pumpers and restricted access to factory premises; that factory management contracted unregulated drilling firms to sink unregistered boreholes that were easy to hide and difficult to detect; and that illegal withdrawals of groundwater could not be traced to tariff and quota-evading pumpers.

A number of inferences may be made from these findings. First, they underscore that the agency in charge of groundwater management must have sufficient autonomy if it is to carry out its task. In practical terms, it must have the power to enforce regulations and a funding base to cover operational expenses. If central or provincial governments are unable to provide the required funds, as is the case in many Asian countries, then the environmental agency must have the power to raise its own revenue in the form of taxes and fines collected from pumpers.

Second, our findings indicate that the tariff instrument must be properly deployed to serve environmental goals. Tariffs provide a source of public revenue and can also serve as a price incentive instrument. Low tariffs provide regulators with operational funds for law enforcement and other tasks. Set at sufficiently high levels, tariffs also provide pumpers with an incentive to economize on groundwater use. OECD country experience shows that many governments have used tariffs as a source of revenue but that they have been reluctant to set tariffs at sufficiently high levels to stimulate conservation among water users (OECD, 1989). The Indonesian experience confirms this trend but also points out the importance of earmarking water tariffs for environmental management lest they disappear in the general treasury.

Third, borehole abstractions provide a case in point of how difficult it is to implement tariff-and-quota systems that require sophisticated monitoring. Implementable policies are policies that take limited regulatory capacity into consideration. It is in this context that waste-water tariffs may have a useful role to play. Waste-water flows are easier to detect than boreholes; regulators do not need to access factory premises to measure volumes of waste-water discharged; and waste-water tariffs can be attached to the waste-water standards regime already in place in many Asian countries. It seems advisable, however, to use waste-water tariffs in conjunction with groundwater tariffs. This will enable regulators to crosscheck reported groundwater withdrawals against reported effluent volume.

Fourth, poor communications are an important source of policy failure in environmental management (Braadbaart, 1995). At present, awareness of the real value of groundwater is low among industrial pumpers. The knowledge of many Indonesian factory managers does not stretch beyond the fact that unless they sink new and deeper boreholes every two or three years their neighbors will draw away all the water. Developing communications channels between government and business is an important component of any groundwater management strategy. For example, part of the groundwater levies might be earmarked for extension, technical advice, or subsidization of groundwater conservation efforts. To some degree, such persuasive measures may soften the impact of the blunt regulatory measures that are needed to stop the urban pumping race.

NOTES

1. *See* OECD (1989), Postel (1988, pp. 317–318).

2. This case rests on primary data we collected during factory and office visits carried out in 1990, 1991 and 1992. Secondary data were supplied by the Jakarta World Bank office, IWACO and the following Indonesian agencies: Environmental Geology Directorate and Mining Bureau, Department of Mines and Energy, and Water Management Office, West Java Provincial Administration. A short field trip undertaken early 1995 enabled the first author to update previous findings.

3. In 1985, manufacturing establishments with 20 or more employees in this threesome produced 54% of national manufacturing value added (Hill, 1990, p. 107).

4. Data sources: Industry Censuses 1974–75 and 1986; West Java in figures (1992); figures refer to establishments with 20 or more workers.

5. Population figures compiled from Hardjono and Hill (1989) and Population Census (1990).

6. For detailed descriptions of the basin's geohydrology see IWACO (1991) and Pulawski and Øbro (1976).

7. Current 1988 Rp (1988 exchange rate US$1 = Rp 1,650), taking into account investment and operation cost over a 10-year period, with discount rate set at 10%. Source: IWACO (1991), Ann.II:95.

8. Fiscal year runs from April to March.

9. These calculations assume the mills working at full capacity and using only groundwater. Data source: World Bank (1991), Vol.II:7–7.

10. To illustrate this point, the information on groundwater quantity changes obtained from the relatively dense networks of observation wells in OECD countries supply information suitable for general policy making purposes only.

11. Other closed pipeline meters that operate on principles other than volumetric, such as electromagnetic meters, may not suffer from these problems but are, from an Asian perspective, prohibitively expensive (Jeffcoate and Pond, 1989).

12. The simplest method is observing the time required to fill a container of a given volume and multiplying this with pumping hours. Another common method is releasing water from a reservoir through a V-shaped notch with vertical markings on it indicating the quantity of water passing at various levels (Groundwater and Wells, 1975, pp. 84–88).

13. For Indonesia see Braadbaart (1995); for Taiwan, Chi (1994); for Hong Kong, Khator, Ng and Chan (1992); for Guangzhou, China, Lo and Tang (1994).

14. OECD country experiences testify that this kind of unified water quantity and quality management can work in practice. See Bhatia, Cestti and Winpenny (1994) and OECD (1989).

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Achieving Balance in Decentralization: A Case Study of Education Decentralization in Chile

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Summary. — Decentralization has been a popular strategy for improving public service delivery, yet it has often failed to live up to its promise. Successful implementation requires the central government to develop new roles which are supportive of decentralization because local institutions generally lack the technical ability and the funds necessary to perform their new functions. Education decentralization in Chile resulted in an appropriate balance of responsibilities between the central government and local institutions. Decentralization had a mixed impact, however, on education quality. Improved monitoring and consistent financial support from the central government is needed to improve equity and raise the quality of education. © 1997 Elsevier Science Ltd. All rights reserved

Key words — decentralization, privatization, education, education finance, bureaucracy

1. INTRODUCTION

Decentralization and privatization of government services have been popular strategies for remedying the problems of governance in both developed and developing countries. The benefits of decentralization in broad terms include greater responsiveness to citizens, improved decision making based on more accurate information and better knowledge of local conditions, and improved efficiency in service delivery — especially when the provision of services is transferred to the private sector (Rondinelli, 1981). Despite these theoretical benefits, decentralization in reality has not fulfilled these expectations (Rondinelli and Nellis, 1986; Bray, 1985; Tanzi, 1995). The so-called failure of decentralization policies, however, has led not to a rejection of the theory, but to greater emphasis on the need to consider the conditions which are necessary for successful implementation of decentralization.

Chile has been recognized for creating innovative social programs that effectively combat poverty (Castañeda, 1992). Decentralization and privatization of the provision of primary health care and education are among these innovative reforms. In the field of education recent efforts to decentralize education curriculum decisions to the school level are only the last of a series of decentralization reforms. The purpose of this article is to document the process of decentralization of education in Chile and to describe the resulting balance of responsibilities between the central government and local institutions. Section 2 reviews the conditions necessary for successful implementation of decentralization policies. Section 3 describes in detail the steps taken in implementing Chile's version of an education voucher system — one of the most unusual education systems in the world. This description confirms some of the generalizations concerning decentralization noted in section 2. In particular, the central government needs to develop its role as supporter of the decentralization process. Section 4 describes how Chile has achieved balance in decentralization by devolving some responsibilities in the provision of education while at the same time expanding financial support and monitoring by the central government. This analysis also determines some measures that could strengthen the impact of decentralization on education quality and equity.

2. IMPLEMENTATION OF DECENTRALIZATION

Rondinelli (1981, 1989) describes four approaches to decentralization: deconcentration, delegation, devolution, and privatization. Deconcentration shifts work loads from a ministry's centrally located offices to staff or offices outside the national capital. Employees are still employees of the central government, however, and generally have little discretion in implementing policies. Delegation is the transfer of

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