8 River Basin Closure and Institutional Change in Mexico’s Lerma–Chapala Basin

Philippus Wester, Christopher A. Scott and Martin Burton

8.1 Introduction

The Lerma–Chapala basin in central Mexico is a telling example of the institutional and political challenges that river basin closure poses, especially for locally managed irrigation. Although rainfall in the past 10 years has been slightly above average, total water depletion in this basin exceeds supply by 9% on average. Groundwater is being mined, with sustained declines in aquifer levels of 1.00–2.58 m/year (Scott and García-Restrepo, 2001), while surface water depletion exceeds supply in all but the wettest years. As a result, Lake Chapala, the receiving water body of the basin, is drying up. In early 2001, the volume of water stored in the lake was around 20% of capacity, the second lowest level recorded since systematic data collection began in 1934. This lake is the largest in Mexico, giving it a high symbolic value, and it generates significant tourism revenue.

Approximately 68% of the annual renewable water in the basin is used to irrigate around 700,000 ha, all of which is locally managed. Since the basin’s water is fully committed, there is no scope for irrigation expansion, and the drilling of new wells and the construction of new dams has been prohibited. Moreover, water pollution is serious, with significant wastewater reuse for irrigation within the basin. Lastly, water is being transferred from agriculture to the urban and industrial sectors, without due compensation to farmers. In sum, the sustainability of locally managed irrigation in the basin is under serious threat, carrying with it grave implications for social equity. Due to basin closure, the poorer segment of the farming community is losing its access to primary water sources as it is diverted to economically higher-valued uses. Consequently, poor farmers increasingly vie for derivative water such as wastewater and drainage effluent (cf. Buechler and Scott, 2000).

In response to the water crisis in the basin, several institutional changes have occurred in the basin since 1989, including the signing of a river basin coordination agreement (1989), the creation of a River Basin Council (1993) and the establishment of aquifer management councils (1995 onwards). Water reforms at the national level, such as the creation of a national water agency in 1989, the decentralization of domestic water supply and sanitation to state and municipality levels (starting in 1983), the transfer of government irrigation districts to users (1989 to present), the creation of state water commissions from 1991 onwards, and a new water law (1992), have also significantly altered institutional arrangements for water management in the basin (González-Villareal and Garduño, 1994). The water reforms in Mexico are driven by the need to deal with increasing water over-exploitation, and influenced by the vested interests of the hydraulic
bureaucracy and the neo-liberal economic policies pursued by the Mexican government (Rap et al., 2003).

This chapter assesses the institutional arrangements for water management in the Lerma–Chapala basin and how well they are dealing with basin closure. It does so by presenting an overview of the basin’s water resources and uses, followed by a section exploring the legal, policy and institutional conditions that influence how the basin is governed and managed. This basin profile provides the backdrop for an analysis of the essential functions for river basin management, after which the key challenges facing the basin, namely surface and groundwater allocation mechanisms and the management of derivative water, are reviewed and conclusions for the future direction of institutional change in the basin are drawn.

8.2 The Lerma–Chapala Water Balance

The Lerma–Chapala basin covers some 54,300 km² and crosses five states: Querétaro (5%), Guanajuato (44%), Michoacán (28%), Mexico (10%) and Jalisco (13%). The basin is home to a dynamic agricultural sector and a growing industrial sector and accounts for 9% of Mexico’s GNP. It is the source of water for around 15 million people (11 million in the basin and 2 million each in Guadalajara and Mexico City) and contains 13% of the irrigated area in the country. The average annual runoff in the basin from 1940 to 1995 was 5,757 million cubic meters (MCM), a little over 1% of Mexico’s total runoff (CNA, 1999a).

The headwaters of the Lerma River rise in the east of the basin near the city of Toluca at an elevation of 2600 m.a.s.l. (metres above sea lever) to discharge into Lake Chapala in the west at an elevation of 1500 m.a.s.l. The total length of the Lerma River is 750 km, and eight major tributaries discharge into it (Fig. 8.1). Lake Chapala, with a length of 77 km and a width of 23 km, is Mexico’s largest natural lake, storing 8125 MCM and covering 111,000 ha when full. The shallow depth of the lake (average 7.2 m)² results in the loss of around

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Fig. 8.1. Topography and stream network of the Lerma–Chapala basin.

1 Percentages indicate the area of the basin that falls in each state.

2 On a scale of 1 : 10,000 the dimensions of the lake are 7.7 m by 2.3 m and less than 1 mm deep.
1440 MCM (million cubic metres; 25% of the annual average runoff in the basin) of its storage to evaporation each year (de Anda et al., 1998). At times of high water levels, Lake Chapala discharges into the Santiago River, which flows in a northwesterly direction and then drops to the Pacific Ocean after 524 km.

The climate in the basin is semiarid to subhumid, with 90% of the rains falling between May and October. Rainfall is highly variable, with an average over the 1945–1997 period of 712 mm/year, a minimum of 494 mm in 1999 and a maximum of 1022 mm in 1958 (CNA, 1999e). Average monthly temperatures vary from 14.6°C in January to 21.3°C in May; thus a range of crops can be grown throughout the year. The potential evapotranspiration mirrors the temperature variation, with a peak in April/May, and an annual total of some 1900 mm. In every month except July and August there is a net deficit between rainfall and potential evapotranspiration, indicating the importance of irrigation.

Forty aquifers have been identified in the basin (CNA/MW, 1999). The upper layer of these aquifers is generally 50–150 m thick and composed of alluvial and lacustrine materials, while the lower layers, several hundred meters in depth, are composed primarily of basaltic rocks and rhyolite tuff. The aquifers are recharged through rainfall infiltration, surface runoff, and, importantly, deep percolation from surface irrigation. Various sources report different data on annual extraction and recharge rates, making it hard to portray with any precision the groundwater situation in the basin. What is clear is that 30 of the 40 aquifers are in deficit, with static water levels dropping at 2.1 m/year on average (Scott and Garcés-Restrepo, 2001). Recent data from the Comisión Nacional del Agua (CNA; National Water Commission) indicate that average annual recharge is 3980 MCM, while average annual extractions are placed at 4621 MCM giving a deficit of 641 MCM, some 71% of the total water deficit in the basin (CNA, 1999a).

Table 8.1 presents current average consumptive water use for different sectors in the basin compared to average annual renewable water, and shows a deficit of 900 MCM. The percentage of available water that is developed and put to use in the basin is 109%, showing its degree of over-commitment. The out-of-basin transfers are to Guadalajara (surface water) and Mexico City (groundwater) for urban water supply.

To portray basin closure in the Lerma–Chapala basin, it is instructive to analyse fluctuations in the water levels of Lake Chapala. Figure 8.2 shows these fluctuations from 1934 to 2000 and relates them to developments in the basin.

Starting in 1945, water levels in the lake declined sharply, from around 97 m on...
average to 90.8 m in 1954, due to a prolonged drought combined with significant abstractions from the lake for hydropower generation. During this period, around 200,000 ha were irrigated in the basin, mainly with surface water, and the constructed storage capacity in the basin was 1628 MCM. This period was the first time the basin headed towards closure as far as surface water is concerned. However, thanks to good rains towards the end of the 1950s, the lake recuperated, and levels fluctuated between 95.5 and 98.5 m from 1960 to 1979.

In 1979, a second period of decline set in, leading to basin closure in the mid-1980s. By this time, constructed storage capacity in the basin had increased to 4499 MCM and the average irrigated area had grown to around 670,000 ha, with a significant increase in groundwater irrigation. Although abstractions from the lake for hydropower generation had ceased, the

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3 Lake elevations are measured relative to a locally defined benchmark where 100 m is set as the high shoreline (de Anda et al., 1998).
combination of these factors resulted in declines in the lake level, from around 95 m at the start of 1980 to 92 m in 1990. After a modest recuperation in the early 1990s, lake levels declined again after 1994, and by February 2001 had fallen to 91.5 m, the lowest level measured since 1954, due to continued over-exploitation of surface and groundwater. It is unlikely that the lake will recover without exceptional runoff, as might be generated by a major hurricane. While the river basin was closing in water quantity terms, water quality also deteriorated severely, with increased effluent discharges and hardly any treatment of urban and industrial wastewater before 1989. Currently, the Lerma River and most of its tributaries are classified as contaminated. Two of its tributaries, the Turbio River and Guanajuato River, are classified as highly contaminated (CNA, 1999a).

### 8.2.1 Irrigated agriculture

The main water user in the basin is irrigation, depleting 59% of total available surface water and 79% of renewable groundwater (Table 8.1). Eleven large-scale canal irrigation systems (termed irrigation districts in Mexico) command around 285,000 ha and some 16,000 farmer-managed and private irrigation systems (termed unidades de riego in Mexico) cover 510,000 ha. Twenty-seven reservoirs with a storage capacity of 250 MCM provide 235,000 ha in the irrigation districts with surface water, whereas around 1500 smaller reservoirs serve 180,000 ha in the unidades. An estimated 26,000 deep tubewells provide around 380,000 ha in the basin with groundwater, of which 47,000 ha are located in irrigation districts (CNA, 1993b; CNA/MW, 1999). In the irrigation districts, there are an estimated 88,000 water users (70,000 ejidatarios and 18,000 pequeños propietarios) compared to 100,000 water users in the unidades (84,000 ejidatarios and 16,000 pequeños propietarios) (CNA/MW, 1999). Detailed data on cropping patterns and productivity for the whole basin are not available, although studies on selected irrigation systems are available (e.g. Kloezen and Garcés-Restrepo, 1998; CNA/MW, 1999; Flores-López and Scott, 2000; Silva-Ochoa, 2000). These studies show that the main crops irrigated in the basin are alfalfa, wheat, sorghum and maize, whereas vegetables and fruits are increasing in importance.

In the early 1990s, the Mexican government transferred the government-managed irrigation districts to water users associations (WUAs) (cf. Rap et al., 2003). Transfer was part of a major reform of the agricultural sector initiated at the highest level of government. Reform was driven by market-oriented economic and political imperatives, and resulted in the following.

- Removal/reduction of direct and indirect subsidies to agricultural production;
- Privatization/elimination of public sector input supply and crop marketing bodies;
- Removal/reduction of tariffs and barriers to agricultural trade;
- Reform of the Mexican Constitution to permit the sale and renting out of ejido land.

The intent of these reforms was to stimulate economic growth through private investment in agriculture. The main objective of the Mexican irrigation management transfer (IMT) programme was to reduce public expenditure on irrigation by creating financially self-sufficient WUAs that would shoulder the full organization and management (O&M) costs of the irrigation systems (Gorriz et al., 1995; Johnson, 1997). Farmers were initially resistant to these changes, but have now generally come to accept them.

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4 Ejidatarios are members of ejidos, land reform communities created after the Mexican Revolution of 1910. Land holdings per ejidatario are typically less than 5 ha. Pequeños propietarios are private farmers with a limit on land ownership of 100 ha; however, holdings may be managed in much larger blocks, with nominal ownership in the hands of family members, friends and others.
In the Lerma–Chapala basin, ten irrigation districts were transferred to farmer management in the early 1990s. WUAs now manage secondary canal units varying in size from 1500 to 30,000 ha. The WUAs were formed as legally recognized non-profit associations to which CNA granted 30-year concessions for the use of water and the irrigation infrastructure. In all the districts, CNA continues to manage the dams and headworks, and in most districts, it manages the main canals and delivers water in bulk to the WUAs as well. However, in the Alto Río Lerma irrigation district, a federation of WUAs has been formed to manage the main system (Kloezen, 2000).

Research carried out by Kloezen et al. (1997) shows that the WUAs in the Alto Río Lerma irrigation district have been effective in improving the provision of services and recovering costs from users. More recent work in the district raises questions about the WUAs’ long-term sustainability (Monsalvo, 1999; Kloezen, 2000). It is important to note that IMT was externally imposed and occurred at a time when the Lerma–Chapala basin was already closed. This has placed a double strain on the newly created WUAs. On the one hand, they have had to learn how to manage sizeable secondary canal units, at which they have been relatively successful, and how to interact with the CNA. On the other hand, they need to organize themselves by establishing relations with WUAs in other irrigation districts to ensure their voice is heard in river basin management discussions.

The management structures in the unidades are much more diverse, and may consist of informal WUAs, government recognized WUAs, water judges, pump groups or commercial management (Silva-Ochoa, 2000). As state intervention in the unidades has been piecemeal in comparison to the districts, and has usually only consisted of assistance in construction and the conces-sioning of water rights, government control over water use in the unidades is much weaker than in the irrigation districts. As a corollary, the representation of unidades in basin-wide decision-making forums is weak.

### 8.2.2 Urban water supply

Domestic water supply in the basin mainly depends on groundwater (95%), with total consumptive use at 791 MCM. In addition, water is transferred out of the basin to provide Guadalajara (237 MCM surface water) and Mexico City (323 MCM groundwater) with urban water. The population in the basin has increased significantly, doubling from 2.1 million inhabitants in 1930 to 4.5 million in 1970 and then more then doubling again to 11 million in 2000 (CNA/MW, 1999). The population of the basin will again double in the next 30 years if the population growth rate of 2.16% remains the same (CNA/MW, 1999). Besides a five-fold increase in population in the past 70 years, the basin’s population has become strongly urbanized. Population in the seven largest cities in the basin increased from 12.7% to 40.9% of the basin’s total population between 1930 and 2000, while the rural population dropped from above 75% to less than 25% during the same period (CNA/MW, 1999). Population growth has led to increasing pressures on the basin’s water resources. Scott et al. (2001) project that urban water demand in the medium term will increase by some 4.1% per year.

Starting in 1983, domestic water supply, wastewater collection, and, more recently, the operational costs of wastewater treatment, were decentralized to municipalities. The creation of water utilities has been

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5 Based on an extensive survey of farmers’ perceptions on changes in irrigation management after transfer, Kloezen et al. (1997) report that 36% of the farmers perceived that water adequacy at field level had improved with IMT, 26% perceived no change and 23% reported it had become worse. According to 64% of the ejidatarios and 47% of the private farmers the condition of the irrigation network had improved, while 54% of the ejidatarios and 38% of the private farmers stated the drainage network had improved. Cost recovery went up from 50% to more than 100%.
promoted to separate these activities from other municipal responsibilities. However, according to CNA (1999d, p. 8) ‘most of the water utilities have a poor performance and need to be greatly improved to achieve technical and economical sufficiency.’

8.2.3 Industry

Although industry only uses a small amount of water (278 MCM or 3% of annual renewable water in the basin), it generates 35% of Mexico’s industrial GNP and pays around US$42 million in water taxes to the federal government (CNA/MW, 1999). The 6400 registered industrial firms in the basin are a major source of water pollution (figures are not available), although officially they must have a permit from CNA indicating effluent standards to discharge wastewater. Fees for discharging wastewater above effluent standards were established in 1991 and updated annually. According to Tortajada (1999), most polluters do not pay these fees, while industries and cities that have submitted wastewater treatment proposals to CNA are exempted from payment.

8.3 The Hydro/Institutional Landscape in the Lerma–Chapala Basin

A watershed year for water management in Mexico was 1989. Whereas the previous 100 years were characterized by increasing federal control over water, since 1989 decentralization has been the norm. Currently states, municipalities and water users have a larger say in water management decision making. The current distribution of competencies in water management in the Lerma–Chapala basin is set out below.

8.3.1 Water rights

In Mexico, surface water is defined in the Constitution as national property placed in the trust of the federal government. As the trustee of the nation’s water, the federal government has the right to concession surface water-use rights to users for periods ranging from 5 to 50 years (Kloezen, 1998). In irrigation districts and unidades, concessions are granted to WUAs and not individual water users. The concession titles set out the volumes of water concession holders are entitled to, although CNA may adjust the quantity each receives annually to reflect water availability, with priority being given to domestic water users (CNA, 1999b). Thus for allocating surface water, Mexico follows the proportional appropriation doctrine and, in theory, all concession holders share proportionally in any shortages or surpluses of water. Once issued, water concessions need to be recorded in the Public Register of Water Rights maintained by CNA. After registration, the concessions become fully tradeable within river basins, although the CNA needs to be notified of trades and needs to approve them (Kloezen, 1998).

The situation surrounding groundwater is more complex, as the Constitution does not define it as national property but rather states that overlying landowners may bring groundwater to the surface as long as this does not affect other users. In 1946, the Constitution was amended to enable the federal government to intervene in aquifers in overdraft by issuing pump permits or declaring that new pumps may not be installed. Based on a ruling of the Supreme Court in 1983, groundwater is now considered national property, although this is not reflected in the Constitution or the 1992 water law (Palacios and Martínez, 1999). Groundwater concessions in Mexico are granted on a volumetric basis, with a

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6 Under the Federal Law on Excise Taxes, updated annually, water users have to pay a tax for the benefits derived from using water, because it is national property. For agriculture a zero rate was established; farmers only have to pay irrigation service fees to WUAs (Tortajada, 1999).

7 This contrasts with the prior appropriation system, where first rights have seniority.
maximum extraction or pumping rate specified.

### 8.3.2 Water management organizations and stakeholders

Numerous stakeholders are involved in water management in the Lerma–Chapala basin. The government agency responsible for water management in the basin is the CNA, a semi-autonomous federal agency falling under the Ministry of Environment. Created in January 1989, the CNA is charged with defining water policy, granting water concessions and wastewater discharge permits, establishing norms for water use and water quality and integrating regional and national water management plans. The aim of unifying all government responsibilities related to water in the CNA was to create the necessary conditions for moving towards sustainable water management (CNA, 1999d). To complement this move, a modern and comprehensive water law was promulgated in 1992 (CNA, 1999c). This law defines an integral approach for managing surface and groundwater in the context of river basins, which it considers the ideal unit for water management. It also promotes decentralization, stakeholder participation, better control over water withdrawals and wastewater discharges, and full-cost pricing.

To discharge its mandate, CNA consists of four levels: federal headquarters, regional offices, state offices and irrigation district offices. Specific responsibilities of the federal headquarters include the following:

- Manage the nation’s water and act as its custodian;
- Formulate and update the National Water Plan and ensure its execution;
- Maintain the Public Register of Water Rights;
- Monitor water taxes payment and send reports to fiscal authorities;
- Facilitate the resolution of, or arbitrate in, water conflicts;
- Promote conservation and efficient use of water;
- Support the development of urban and rural domestic water supply and drainage and sanitation networks, including the treatment and reuse of wastewater;
- Support the development and management of irrigation and drainage systems and storm and flood protection works.

To facilitate river basin management and interaction with stakeholders, CNA has divided the country into 13 hydrologic regions based on river basin boundaries and established an office in each region. These regional offices have been delegated responsibilities from the national level and are relatively autonomous. Their main responsibilities include the following:

- Organize and manage CNA’s actions at the regional level concerning the planning, execution and evaluation of the Regional Water Plan;
- Integrate and validate requests for water concessions (users), allocations (municipalities) and permits (groundwater and wastewater), issuing those that fall in its competency and forwarding to HQ those that do not;
- Supervise the Public Register for Water Rights offices at the state level, and consolidate and send to HQ all information necessary to keep the Register updated at the national level;
- Assist CNA state offices in their collection of water taxes from users;
- Integrate and update programmes for the operation, maintenance and rehabilitation of irrigation districts and water treatment plants;
- Supervise and assist in the operation of climate and river flow measuring networks;
- Enforce legal standards concerning water pollution and wastewater discharges.

Responsibilities for water management at the state level are more diffuse. CNA has established offices in Mexico’s 31 states that function under the supervision of the regional offices. The role of state governments, as opposed to the federal
government, in water management has been limited to regulating municipal water utilities and supporting utilities showing poor technical and economic performance. As part of the ‘new federalism’ policy during the Zedillo administration (1995–2000), the federal government promoted delegation of responsibilities and programmes to the states, but, notably, not financial resources. Although the federal government has encouraged the modification of state laws to promote the participation of state governments in water management through the creation of State Water Commissions, the response has been lukewarm. This is not the case in Guanajuato, where CEAG (Comisión Estatal del Agua de Guanajuato; Guanajuato State Water Commission) has taken on its new role with vigour (Guerrero-Reynoso, 2000). The relationship between the State Water Commissions and the CNA still needs to be defined.

At the irrigation district level, CNA and WUAs share responsibility for water management. According to the 1992 water law and the WUAs’ concession titles, CNA remains the authority in the irrigation districts. The CNA Irrigation District Office retains the following responsibilities and powers:

- Notify the WUAs on the volume of surface water they have been allocated for the coming year;
- Operate and maintain the dams and headworks of their irrigation district and also the main system if a federation of WUAs has not been established;
- Approve irrigation service fee levels, determined by the WUAs according to the procedures outlined by the CNA in the concession title;
- Establish and periodically revise the instructions for the operation and maintenance of the secondary canal units managed by WUAs;
- Approve the WUAs annual maintenance plan and ensure that it is carried out satisfactorily;
- Participate in the General Assembly of the WUAs with the right to speak but not to vote;
- Cancel or refuse to renew concession titles if WUAs perform unsatisfactory.

Based on the concession granted to them by the CNA, WUAs legally assume the responsibility to operate, maintain and administer their secondary canal unit. Their specific responsibilities to the CNA are the following:

- Develop and enforce bylaws that detail procedures for water distribution, system maintenance and investment, cost recovery, and dealing with complaints and sanctions;
- Collect irrigation service fees that fully cover the O&M and administration costs of the WUA;
- Pay CNA a percentage of the revenues from fee collection for CNA services related to O&M of the dams, headworks and main canal system;
- Prepare annual operation and maintenance plans and budgets and send to CNA for approval.

At the river basin level, an important innovation has been the creation of river basin councils. The water law stipulates that stakeholder participation is mandatory in water management at the river basin level. To this end river basin councils, defined in the water law as coordinating and consensus-building bodies between the CNA, federal, state and municipal governments, and water user representatives (CNA, 1999c), have been established by CNA in 25 river basins (CNA, 2000a). The stated goal of the councils is to foster the integral management of water in their respective river basins through proposing and promoting programmes to improve water management, develop hydraulic infrastructure and preserve the basin’s resources. Formally, the river basin councils have little decision-making power, as CNA remains responsible for water concessions, the collection of water taxes and water investment programmes. The role of the councils is to assist CNA in the execution of its vested powers and to ensure that CNA takes stakeholders’ opinions into account (CNA, 2000a).
Mexico’s first river basin council was established in the Lerma–Chapala basin in response to the dropping level of Lake Chapala in the 1980s and the severe contamination of the Lerma River (Mestre, 1997). In April 1989, the federal government and the five state governments signed a coordination agreement to improve water management in the basin by: (i) allocating surface and groundwater fairly among users and regulating water use; (ii) improving water quality by treating effluents; (iii) increasing water-use efficiency; and (iv) conserving the river basin ecosystem and watersheds. Based on this agreement, a formal Consultative Council was formed in September 1989 to follow up on these objectives. Based on the 1992 water law the Consultative Council became the Lerma–Chapala River Basin Council on 28 January, 1993.

In the past 10 years, the River Basin Council has been in flux, and only in August 2000 was its structure formalized (CNA, 2000a). It now consists of a Governing Council, a Monitoring and Evaluation Group (MEG), a Basin Level User Assembly and Special Working Groups, while the CNA’s regional office forms the Council’s secretariat (Fig. 8.3). The Governing Council is chaired by CNA, while user representatives from six sectors (agriculture, fisheries, services, industry, livestock and urban) and the governors of the five states falling in the basin are its members, yielding a total of 12 members. Although agriculture uses 68% of the annual renewable water in the basin, it only has one vote out of 12 on the Council. The decision-making body of the River Basin Council is the MEG, which is a carbon copy of the Governing Council except that state governors send representatives in their stead, while CNA is represented by the head of its regional office. The MEG meets on a regular basis to prepare and convene Council meetings and more importantly to draft agreements to be signed at formal Council meetings.

The structure of the River Basin Council is complemented by a stepped form of user representation, consisting of water user committees for the six water use sectors represented on the Council. These committees can be formed at the regional, state or local level, building on already existing WUAs or other legally recognized water management groups where possible. The water user committees form the Basin Level User Assembly, which elects the six user representatives on

Fig. 8.3. Structure of the Lerma–Chapala River Basin Council.
the Council. In addition, forums at the sub-basin level, such as watershed commissions and aquifer management councils, form part of the structure of the River Basin Council (Fig. 8.3).

8.4 Essential Functions for River Basin Management

As set out in Chapter 1, a set of essential functions has been posited to analyse the institutional arrangements for river basin management. A list of these functions as they apply in the Lerma–Chapala basin, crossed with the key actors identified in the previous section, is shown in Table 8.2. Cells are marked to indicate if an actor is active in a particular functional area, while action verbs such as Execute (E), Supervise (S), Advise (A), Authorize (Aut), Regulate (Reg) and Represent (Rep) are used to describe the nature of an actor’s activities or responsibilities. The table, together with the description of the actors, gives an indication of which essential functions are accounted for and who is involved in their execution. In itself, this is useful to identify whether certain essential functions are not being executed. A number of interesting points emerge from Table 8.2:

- Most of the essential functions relating to surface water are covered.
- The withdrawal and distribution of groundwater is weakly regulated, and the construction of new facilities continues although this has been prohibited.
- Monitoring and ensuring the quality of primary water sources are relatively weak functions. Stopping groundwater pollution is a function that is not covered at all.
- The monitoring of wastewater quality and enforcing wastewater discharge norms are also functions that receive little attention, while the allocation and distribution of wastewater in the basin is not regulated at all and left to actors on the ground.
- Industries and non-governmental organizations (NGOs) are hardly involved in water management in the basin.

Another, perhaps more interesting, question is how efficiently the functions are executed and if they are effective. To evaluate how well the functions are being performed, an evaluation matrix was developed and applied to the Lerma–Chapala basin. This matrix consisted of eight variables for each essential function, four related to effectiveness and four related to efficiency. For each variable, three questions were formulated that could be answered on a scale of 1 to 5, giving a maximum score of 60 points for effectiveness and 60 points for efficiency per function. The scores per function can be set out against each other, with effectiveness on the x-axis and efficiency on the y-axis, yielding a graphical representation of how well the functions are executed (Fig. 8.4). The scores presented in Fig. 8.4 are the averages of the responses given by 15 key water management stakeholders in the basin. Although a drawback of the evaluation matrix is that it did not distinguish between surface and groundwater or between primary and derivative water sources, it is presented here as it reflects overall impressions of key water management actors in the Lerma–Chapala basin regarding the execution of the essential functions in their basin. An interesting point that emerges from Fig. 8.4 is that none of the essential functions are executed efficiently according to key water managers in the basin. What also stands out is that, apart from protecting the environment, the effectiveness of the execution of the essential tasks is moderate. The next section presents more detail on the overarching issues facing the basin.

8.5 Over-arching Issues

Through steady changes in the institutional arrangements in the Lerma–Chapala basin in recent years, progress has been made towards improved water management. This progress is significant, in light of the
Table 8.2. Key actors and essential basin management functions in the Lerma–Chapala basin.

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<th>Key actors</th>
<th>Surface water</th>
<th>Groundwater</th>
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<td>Plan (basin-level)</td>
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E, Execute; S, Supervise; A, Advise; Aut, Authorize; Reg, Regulate; Rep, Represent; CNA, Comisión Nacional del Agua; WUA, water users association; NGO, non-governmental organization.
complicated transition from highly centralized water management to one in which states, municipalities and water users have a larger say. Nonetheless, from a water perspective the Lerma–Chapala basin is still in crisis. The efforts of the Council over the past 10 years need to be redoubled to tackle the significant challenges lying ahead of it. Three challenges stand out, namely the allocation of surface water and groundwater, and the management of derivative water.

8.5.1 Surface water allocation

To allocate surface water in the basin, the governors of the five states in the basin and the federal government signed a treaty in August 1991 (CCCLC, 1991). An important objective of the treaty is to maintain adequate water levels in Lake Chapala and to ensure Guadalajara’s domestic water supply. To preserve Lake Chapala, the treaty sets out three allocation policies, namely critical, average and abundant, based on whether the volume of water in the lake is less than 3300 MCM, between 3300 and 6000 MCM, and more than 6000 MCM, respectively. Each year the Council verifies the volume stored in Lake Chapala to determine the allocation policy to be followed for the next year. For each allocation policy, formulas have been drawn up to calculate water allocations to the irrigation systems in the basin, based on the surface runoff generated in each of the five states in the previous year. Table 8.3 indicates how this works for the Alto Río Lerma irrigation district. Based on extensive modelling of these formulas, it was concluded that the resulting water allocation would not impinge on the 1440 MCM needed by Lake Chapala for evaporation. Thus, as shown in Table 8.3, if the surface runoff generated is below a certain threshold, a fixed volume is deducted from the irrigation district’s allocation so that this can be passed on to the lake.

Since 1991, the MEG of the Council has met each year and has applied the water allocation rules set out in the treaty. Figure 8.5 sets out the volumes of water allocated and used from 1992 to 2000, as well as the volume of water stored in Lake Chapala. This shows that the 1991 treaty has been
enforced, as actual use has never been higher than the allocated values. A caveat here is that only the extractions by irrigation districts are accurately measured, thus actual withdrawals may have been higher as the amount of water going to the unidades de riego is unknown.

Despite the apparent compliance with the surface water treaty, Lake Chapala’s volume has halved in the past 8 years. This is so, in part, because the treaty takes the surface runoff generated in the previous year to determine water allocations. In 1997 rainfall was only 645 mm (against the average annual value of 712 mm) and dam storage (used here as a proxy of surface runoff) was consequently low. Combined with a lake volume below 3300 MCM, the critical allocation policy was followed for 1998, leading to the lowest allocations since the treaty was signed. However, rainfall in 1998 was exceptionally good, at 810 mm some 100 mm above average, leading to a recuperation of the volume of water stored behind dams and a slight increase in the volume of Lake Chapala to 3361 MCM. As a result, the average allocation policy was followed for 1999 and 3664 MCM were allocated to water users, the highest level since the signing of the treaty. Unfortunately, rainfall in 1999
was a historic low of 494 mm. These two factors resulted in Lake Chapala dropping to its lowest level since the signing of the treaty and point to inadequate provisions in the treaty for inter-annual planning of water availability and dealing with contingencies.

The members of the Council have recognized the shortcomings of the surface water treaty and in 1999 decided to revise the treaty, as it was clear that it was not rescuing Lake Chapala. In 1999 and 2000, detailed studies were carried out with hydrological data from 1945 to 1997 (an improvement over the 1950–1979 data used for the previous treaty) to develop a new model for calculating surface runoff (CNA, 1999e). The Council signed the amendment of the 1991 surface treaty on 24 August, 2000 (Consejo de Cuenca Lerma–Chapala, 2000). However, various states in the basin feel that they did not have sufficient input in the design of the surface runoff model and that CNA imposed the treaty on them. In addition, consultation with water users concerning the new treaty has been minimal, although user representatives on the Council voted in favour. Although the signing of the new treaty shows the adaptability of the Council and the commitment of its members to construe a water allocation policy that meets urban and agricultural needs while safeguarding the environment, the process by which it was arrived at is contested.

An issue that the Council has not yet started to consider is how to compensate farmers for water transferred out of agriculture for urban and environmental demands. Scott et al. (2001) calculate that the benefits forgone for farmers in the Alto Río Lerma irrigation district as a result of a reduced water allocation to the district for 1999/2000 amounted to US$14 million. Although sufficient water was stored in the district’s reservoirs to cover its full allocation (955 MCM) the district was allocated only 648.2 MCM under the treaty, due to the critically low volume of water in Lake Chapala and the minimal surface runoff generated in Guanajuato in 1999. To shore up water levels in Lake Chapala, the CNA released 240 MCM from the district’s main reservoir into the Lerma River in October 1999, thereby transferring surface water from the agricultural sector to the urban and environmental sector.

The reduced allocation to the Alto Río Lerma irrigation district in 1999 resulted in some 20,000 ha out of a total of 77,000 ha not being irrigated with surface water in the winter season. Four of the 11 WUAs in the district went without irrigation altogether, whereas in the other WUAs, irrigation was restricted to a maximum of 3 ha per landowner. For many of the better off farmers who could switch to groundwater, this was not too problematic, but for many poorer farmers who mainly rely on surface water, the results were disastrous. In addition, many poor farmers who traditionally pumped return flows from the Lerma River were hard hit as the use of this precarious source of water was prohibited and enforced through army patrols along the river. The surface water allocations for all the irrigation districts in the basin for the 2000/01 winter season were so low that the WUAs decided to let 200,000 ha (of a total of 235,000 ha in the irrigation districts normally irrigated with surface water) lie idle. Once again, poor farmers were hardest hit. On the other hand, Lake Chapala has dropped to its lowest levels in 50 years, and environmental NGOs and the Jalisco state government are demanding the transfer of water stored behind the dams of the irrigation districts to the lake.

The lack of water in the past 2 years has galvanized WUA leaders to take action. In May 2000, the presidents of WUAs located in Jalisco, Guanajuato and Michoacán met each other for the first time to discuss ways to strengthen their representation in the River Basin Council. Until then, WUAs of a particular irrigation district had dealt only with the CNA, are there were no horizontal linkages between WUAs from different district. In 2001, WUAs from irrigation districts in Querétaro and Mexico joined the discussions, and the combined WUAs established a new working group in the River Basin Council focussing on agriculture. They have vowed that not a single drop of water will be passed to Lake Chapala and have threatened civil disobedience if CNA transfers water as
in October 1999. It is clear that a serious conflict is brewing in the basin surrounding surface water and that the Council needs to act fast to come up with a workable solution. What is more worrisome is that the lack of surface water has led many farmers to increase their use of groundwater, while aquifers are already in perilous decline.

8.5.2 Groundwater management

The serious overdraft of the basin’s aquifers is arguably a more pressing issue than surface water allocation. Although the Council signed a coordination agreement to regulate groundwater extraction in the basin in 1993, progress on the ground has been slow (CCCLC, 1993). A key problem is that the Council, through the CNA, does not physically control the water extraction infrastructure (the wells), as it does in the case of surface water (the dams). Although the Constitution mandates the federal government to intervene in aquifers in overdraft by placing them under veda, prohibiting sinking of new wells without permission from the federal government, the experience with vedas has been disappointing (Arreguín, 1998). The reality of groundwater extraction in Guanajuato clearly shows how groundwater regulation by the federal government has run aground. According to Vázquez (1999) ten vedas were issued in Guanajuato between 1948 and 1964 prohibiting the drilling of new wells in large parts of the state, and in 1983, the remainder of the state was placed under veda. Notwithstanding these legal restrictions, the number of wells in Guanajuato increased from approximately 2000 in 1958 to 16,500 in 1997 (Guerrero-Reynoso, 1998).

Based on the recognition that vedas have not worked and to counter the continued depletion of groundwater in the basin, CNA started promoting the formation of Comités Técnicos de Aguas Subterráneas (COTAS; aquifer management councils) in selected aquifers in 1995, as an outgrowth of the 1993 agreement. Through the establishment of COTAS, which fall under the River Basin Council, the CNA is seeking to stimulate the organized interaction of aquifer users with the aim to establish mutual agreements for reversing groundwater depletion, in keeping with Article 76 of the water law regulations (CNA, 1999c). Based on recent developments in the State of Guanajuato, where CEAG enthusiastically promoted the creation of COTAS (Wester et al., 1999; Guerrero-Reynoso, 2000), the structure of the COTAS has been defined at the national level in the rules and regulations for river basin councils (CNA, 2000a).

In these rules, the COTAS are defined as full-fledged user organizations, whose membership consists of all the water users of an aquifer. They are to serve as mechanisms for reaching agreement on aquifer management taking into consideration the needs of the various sectors using groundwater (CNA, 2000a).

To date, 17 COTAS have been formed in the basin. However, none of them has yet started to devise ways to reduce groundwater extraction. Considering that some 380,000 ha in the basin are irrigated with groundwater and that industrial and domestic uses depend almost entirely on groundwater, it is fair to say that groundwater is the strategic resource in the basin, particularly from a water productivity perspective. The long-term consequences of its continued depletion easily overshadow those of Lake Chapala drying up. Although the COTAS are a timely institutional response to the pressing need for innovative approaches to managing aquifers in the basin, it remains to be seen if they will succeed in reducing aquifer over-exploitation. Current discussions in the COTAS focus on installing sprinkle and drip irrigation systems to save groundwater, but the tough issue of how to reach agreement on an across the board reduction in pumping has not yet been broached. In addition, new pumps continue to be installed and regularized through extra-legal means. The reluctance of the government to impose strict pumping limits and the continued race to the pumphouse by farmers bode ill for the COTAS.
8.5.3 Management of derivative water

The effects of the new institutional arrangements in the basin on surface and groundwater management were briefly described above. The picture that emerges is that, although some progress has been made, the basin’s primary water sources are still seriously overdrawn, to the particular detriment of poorer farmers. For them, derivative water is becoming a critical, and frequently the only, available source of water (cf. Buechler and Scott, 2000). In 1993, the municipal wastewater flow generated in the basin was estimated at 12,700 l/s, and by 1997, this had risen to 17,000 l/s, which is equal to around 536 MCM per year (Mestre, 1997). The return flows from agriculture are not measured, but the fact that hardly any water flows into Lake Chapala suggests that, whatever the magnitude of the return flows, they are used upstream. The extent of wastewater irrigation in the basin has not been accurately assessed, but estimates range from 20,000 to 40,000 ha (CNA/MW, 1999).

The use of return flows and wastewater is currently a free-for-all and is not formally regulated by the institutional arrangements for water management in the basin. However, as Buechler and Scott (2000) outline, farmers at times need to obtain informal permission from municipalities or WUAs to use wastewater. These claims are being threatened by the construction of wastewater treatment plants and the de facto reallocation of treated water to other uses.

In 1989, the River Basin Council launched an investment programme to clean the Lerma River through the planned construction of 48 treatment plants with a capacity of 3700 l/s. Priority was given to cities with more than 10,000 inhabitants that discharged directly into the Lerma River or Lake Chapala. This was essential, as up to 1989 hardly any of the municipal and industrial wastewater in the basin was treated. As a result, large stretches of the Lerma River were heavily contaminated, as were two of its tributaries, the Turbio and Querétaro Rivers, while Lake Chapala was classified as contaminated. On 28 January, 1993, the river basin council agreed on a second water treatment programme, entailing the construction of 52 new plants and the enlargement of five existing ones, with a combined treatment capacity of 10,835 l/s (Mestre, 1997). It was foreseen that the two investment programmes would create a total treatment capacity of 14,561 l/s, representing 85% of municipal wastewater generated in the basin. At the end of 1999, 48 plants had been constructed with a treatment capacity of 6037 l/s, while six additional large plants are still under construction, with a capacity of 3155 l/s (CNA, 1999a). Of the installed capacity of 6037 l/s, only 3155 l/s provides full treatment. Although the River Basin Council has not succeeded in attaining the ambitious goals it set for itself, the installed capacity of 6037 l/s, up from 0 l/s in 1989, is an achievement in itself. The council readily admits that more needs to be done, although the large investments required and the lack of financial resources at the basin level makes this difficult (CNA, 1999a).

Scott et al. (2000) place the value of wastewater irrigation for 140 ha of irrigated land that depend on the City of Guanajuato for their water at some US$252,000 per year. As part of the Council’s water treatment programme, Guanajuato City is in the process of contracting for an activated sludge wastewater treatment plant and plans to sell the treated water to commercial interests. As a result, farmers will lose their access to wastewater as well as the nutrient benefits of that water. This raises the question how a de facto right to derivative water should be addressed when water treatment redirects wastewater outflows. Although the CNA, the River Basin Council and the State Water Commissions are actively pursuing the construction of wastewater treatment plants, the allocation and distribution of derivative water has received no attention. In closing river basins, where primary water sources have already been captured by the better off and renegotiating water rights is extremely complicated, derivative water rapidly becomes the poor farmer’s last resort and should be recognized as such.
8.6 Conclusions

This chapter has explored the dynamic interplay between trends in water use and institutional changes for water management in the Lerma–Chapala basin. Drought and water shortages between 1945 and 1954, resulted in a doubling of the reservoir capacity within the basin. Pressures on available primary water, both surface and ground, continued to increase with the irrigated area increasing almost fourfold up to 1989 and population increasing almost threefold. After primary water resources had become over-committed, institutional reforms were introduced from 1989 onwards devolving responsibility for water management in irrigation systems to water users and initiating participatory water management bodies at the basin level for high-level decision making on water allocation.

A central component in this reform has been the 1992 water law, though of equal importance have been the institutional capability to put the law into practice, and institutions ability to adapt to a dynamic situation with additional measures for controlling and managing available surface and groundwater resources. The assessment of the institutional arrangements for water management in the Lerma–Chapala basin brings out clearly the need for coordinating mechanisms at the basin level in river basins facing closure. Through the Lerma–Chapala River Basin Council, progress has been made towards improved water management in the basin. This progress is encouraging, in light of the complicated transition from a highly centralized management of water resources to one in which states, municipalities and water users have a larger say. Though the institutional measures have had a significant impact in restructuring water management, the basin is still in crisis, with the level of Lake Chapala in perilous decline and aquifers running dry. The efforts of the River Basin Council over the past ten years will need to be redoubled to tackle the significant challenges lying ahead of it.

Although surface water allocation mechanisms are working, and the revision of the 1991 treaty may lead to increased inflows to Lake Chapala, compensating farmers for water transferred out of agriculture needs to be considered. In closed basins, inter-sectoral transfers are inevitable and it will invariably be the irrigation sector that will need to cede water. A key institutional challenge in closed river basins is dealing with these transfers in a just and equitable manner, such that the sustainability of locally managed irrigation is ensured. The Lerma–Chapala River Basin Council could be a forum for drawing up and enforcing compensation mechanisms for surface water transferred out of agriculture, but to date it has been reluctant to consider this issue due to the costs involved. To be credible and effective partners in basin management, WUAs and farmers need to make concerted efforts to reduce water use, for which there is real scope, and to join forces to argue their case more strongly in the River Basin Council.

A much more serious challenge that the Council and other water management stakeholders in the basin need to deal with urgently is the overdraft of the basin’s aquifers. The aquifer management councils are a step in the right direction, but their role in groundwater management should go beyond mere consultation. Bundling extraction rights in an aquifer and concessioning this to a COTAS is feasible under the Mexican water law and should be seriously considered. Placing aquifer management in the hands of the aquifer users, under the supervision of the River Basin Council, State Water Commissions and the CNA, shows more promise of reducing extractions than the current system of vedas and federal regulation.

With basin closure, poorer farmers in particular are losing, or have lost, their access to primary water due to reductions in surface irrigation and increased costs for groundwater irrigation. Hence derivative water, both wastewater and agricultural drainage effluent, is increasingly becoming a critical resource for poor farmers. However, its allocation in the basin is currently a free-for-all. Although progress has been made in constructing wastewater treatment plants, the management of derivative water has
received little attention. More generally, meeting the water needs of poor people, and including poor women and men at all levels of water management decision making, is not a priority of the Council, nor is it a strong feature of the larger set of institutional arrangements for water management in Mexico. The Council needs to seriously consider how to safeguard and improve the access of the poor to water, and how to combat the current de facto concentration of water rights in the hands of the few. Overall, a coherent approach for tackling the continued pressures on the basin’s primary water sources, the significant re-use of wastewater (derivative water) and the deterioration of water quality needs to be developed.

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