Five-Country Regional Study on the Development of Effective Water-Management Institutions: A Synthesis of Findings from the Case Studies

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This paper synthesizes the findings from case studies of five river basins in Asian countries, carried out by IWMI in collaboration with national research institutions. The case studies were part of a five-country regional study financed by the Asian Development Bank (ADB) on the development of effective institutions for managing water resources for agriculture in water-scarce river basins. The following river basins were selected for study: Fuyang river basin in the People's Republic of China, Upper Inderagiri (Ombilin) in Indonesia, Upper Pampanga in the Philippines, East Rapti in Nepal, and Deduru Oya in Sri Lanka. In 2001, two basins from Thailand, Mae Klong and Bang Pakong, were included as additional sites.

The overall objective of the study was to improve the management of water resources available for agriculture in river basins where there is growing inter-sectoral competition for water, and associated environmental, socioeconomic and institutional issues arising from such water scarcity.

The specific objectives of the study were:

- To carry out a detailed analysis of existing institutional arrangements for water-resources management in selected river basins, with a view to identifying the extent to which they constrain and facilitate decision making related to agricultural water management, especially in the context of inter-sectoral competition for water.
- To apply and validate a conceptual framework for analyzing the institutional arrangements for water-resources management.
- To develop and initiate the implementation of policies and institutional strengthening programs that will lead to improved management of water available for agriculture.

In addition to these country studies, three supplementary case studies were conducted. Two of these were on river basins from developed countries, Murray-Darling in Australia and Omonogawa in Japan. The main objective of the two case studies on developed-country river basins was to identify key elements of successful water-resources management that may be relevant as lessons for developing countries. The third supplementary case study was the Brantas basin in Indonesia. This case study, conducted in cooperation with the Jasa Tirta Corporation, which manages major hydraulic works in the basin, was to examine how an

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effective institutional framework and a basin organization have been developed and installed to cover multiple uses of water in a large river basin in a developing country.

Methodology. In order to provide a unifying element to the study, a common methodology and a set of research questions were adopted (Samad and Bandaragoda 1999). The key components of the methodology were:

- compiling an inventory of the physical infrastructure related to water resources in the river basin
- water accounting
- analysis of the prevailing socioeconomic conditions in the basin
- assessing the current performance of irrigated agriculture in the basin
- analysis of the existing formal and informal institutional arrangements for managing water resources in the river basin and documenting how different stakeholders are included or excluded in water-resources development and benefit appropriation strategies

Physical Characteristics of the Basins

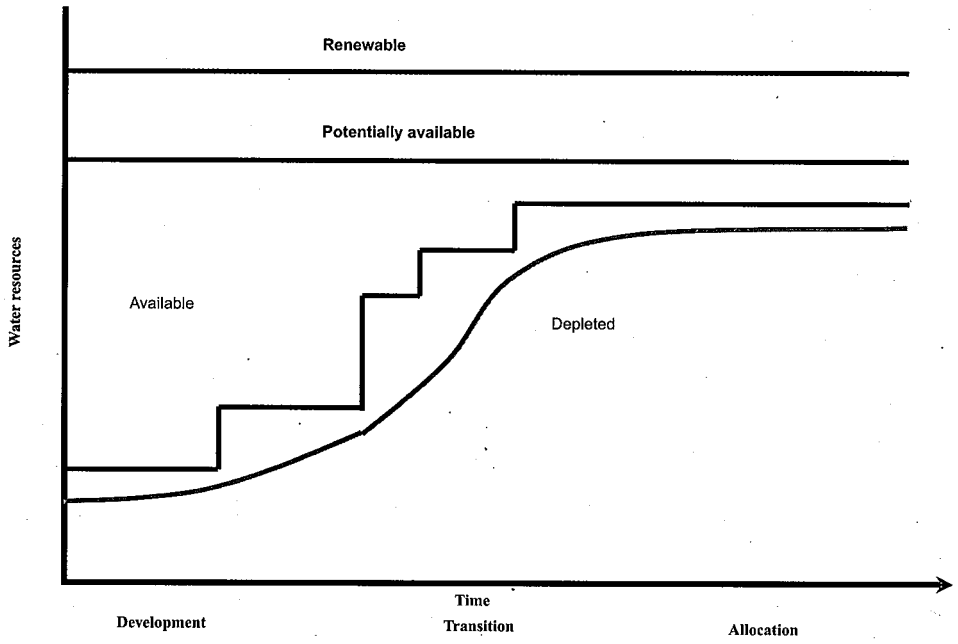
A working hypothesis of the study is that river basins evolve and change over time from both a biophysical and a socioeconomic perspective. Figure 1 illustrates the hypothetical development path of a river basin as defined by Molden et al. (2001). Three distinct stages in the development of water resources in river basins were specified:

- development or construction stage
- transition stage where the emphasis is on managing supplies and water savings
- allocation stage in which the river basin has become "closed" in the sense that all available water has been allocated to various uses

In the *development stage* water tends to be plentiful and low in value. Conflicts are few and the need for coordination among sectors limited. At the other extreme, in the *allocation stage* water is scarce and valuable, with a high potential for conflicts among users. Controlling pollution and water quality is a major problem. A paramount task at this stage is setting priorities for the allocation of water among sectors—irrigation, domestic, industry and environment.

Figure 2 categorizes the five selected river basins in terms of their development stages and highlights salient features. The categorization is based on the results of the water accounting conducted in each basin. The five sites chosen reflect a full range of stages in the development of river-basin water resources. A cross-site comparison of the five basins allows us to develop a perspective on the problems occurring in various stages as a river basin evolves.

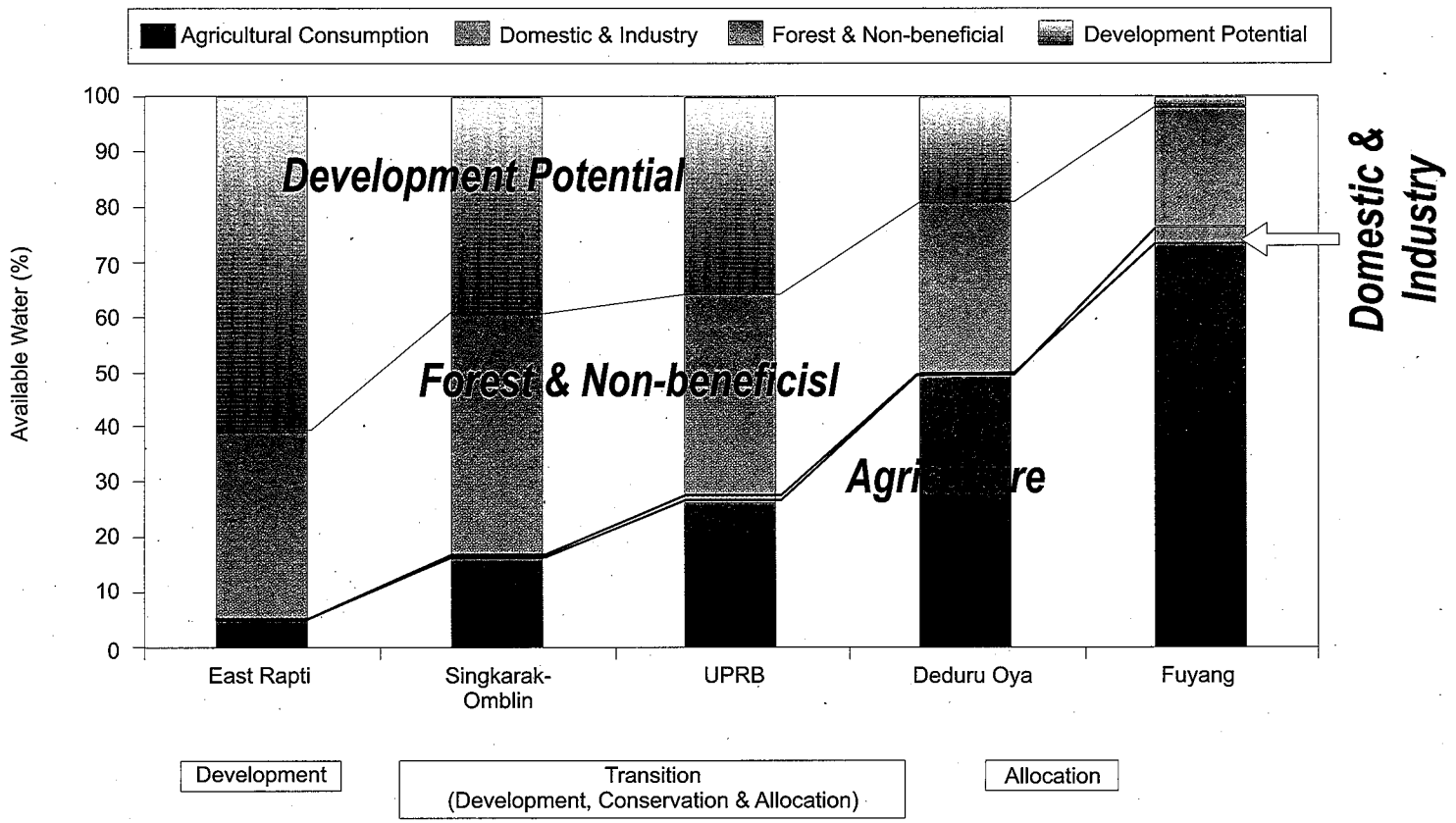
Figure 1. Basin development stages.



The East Rapti river basin in Nepal is an open basin, relatively underdeveloped but well endowed with water resources. Water availability is estimated at about 9,000 m^3 per person per year. In East Rapti there is a very large potential for further development of water resources, but moving from left to right, the potential steadily declines until in Fuyang there is virtually no potential for further development of water resources. With an annual per capita water availability of about 400 m^3, it is one of the most water-short regions in North China. Nonetheless, water demand in this basin for domestic and industrial requirements is quite low. The results suggest that compared to domestic and industrial needs, the requirements for the environment, in particular trees, may be fairly large.

The other three basins fit in-between these two extremes, as indicated in figure 1, and display varying stages of development and levels of water scarcity. The Upper Pampanga basin is relatively well endowed with water, with per capita water availability exceeding 3,500 m^3. The Deduru Oya basin (1,046 m^3/per capita/annum) in Sri Lanka is seasonally water-scarce, especially during the peak of the dry season when there is hardly any river flow. It is also spatially water-scarce, especially in the midstream region of the basin that is predominantly in the drier region of the basin. The Ombilin subbasin located in the upper reaches of the Inderagiri river basin in West Sumatra, Indonesia is an "open basin." But, while there is inter-sectoral competition for water, there are also water-related conflicts.

Figure 2. Development stages of the five basins and sectoral water use.



Socioeconomic Characteristics

Table 1 gives the salient demographic features of the basins. The populations in all five basins are concentrated in rural areas. The Fuyang river basin is the most densely populated and East Rapti the least. In the Deduru Oya basin, there is a heavier concentration of population in the head and tail-end areas, which are more urbanized than the middle region of the basin. High population growth has been reported in East Rapti and Upper Pampanga, 2.7 and 2.9 percent, respectively, per annum in the two districts in East Rapti (Ghimire et al. 2000) and 2.9 percent per annum in Upper Pampanga (Orden et al. 2000). (Comparable data on population growth rates for the Fuyang basin and Ombilin are not available). In Deduru Oya, there is an overall decline in the population growth rates but there is evidence of an increase in population in the more urbanized areas, suggesting an increase in rural-urban migration. Population growth, especially growth in the urban population, will result in an increase in the demand for water supply for domestic purposes.

In all locations, statistics on employment specific to the basin are not available. However employment data from the various administrative areas that fall within the basin indicates that overall, agriculture is the major source of employment of the inhabitants of the respective basins. The proportion of the population dependent on agriculture varies from 40 percent in Deduru Oya to 79 percent in East Rapti.

Incidence of Poverty

The lowest incidence of poverty is in the Fuyang basin with only 6 percent of the population living below the official poverty line. In three other locations, the incidence of poverty is high: Pampanga, 39 percent; East Rapti, 42 percent; and Deduru Oya, 60 percent. Detailed information on poverty is given only in the Sri Lankan and Nepal case studies.

In the Deduru Oya basin, pockets of poverty have been reported from the principal urban center, Kurunegala. The other location where poverty is more pronounced is in the midstream area of the basin where there is acute scarcity of water, especially in the dry season. In the latter case, poverty is attributed to low agricultural-productivity levels due to water scarcity.

In East Rapti, poverty is more pronounced in the rural areas than in the urban centers. Besides locational effects, there are also strong caste and ethnic dimensions to the poverty problem. Certain groups classified as "primitive" and leading a mostly nomadic life are among the worst affected. The incidence of poverty is reportedly high among the ethnically disadvantaged groups, especially among fisherfolk communities. This is primarily due to the decreasing fish population in the river, caused by overfishing and by water-quality problems resulting from the discharge of industrial effluents into the river.

Table 1. Salient socioeconomic features in the selected river basins.

Characteristics	Fuyang (China)	Inderagiri-Ombilin (Indonesia)	Upper Pampanga (Philippines)	East Rapti (Nepal)	Deduru Oya (Sri Lanka)
Total population (millions)	15.6	0.7	1.5	0.6	1.0
Population density (persons/sq. km)	686	396	450	212	378
No. of urban centers	4	4	3	3	22
No. of villages	9,092	400	325	na	2,807
Urban population (%)	28	na	36	25	10
Rural population (%)	72	na	64	75	90
Per capita availability of water (m^3)	868	na	3,630	9,034	1,046
Urban households having piped water (%)	97	na	27	36	21
Rural households having piped water (%)	77	na	na	na	9
% employed in agriculture	67	59	61	79	40
Proportion of population living below national poverty line (%)	6	na	39	42	60

Performance of Irrigated Agriculture

Deduru Oya

A unique feature of the Deduru Oya basin is water scarcity in the midstream region. This area has the highest concentration of small tank systems in the entire basin. Water scarcity has seriously affected irrigated agriculture in the small tank systems. Rice is the main crop cultivated under irrigation in both the wet and the dry seasons. In some of the water-scarce areas, non-rice crops are grown in the dry season.

In recent years, there has been an increase in groundwater abstraction using diesel- and petrol-powered pump sets. These are used primarily for nonagricultural purposes such as brick-making. In some places, water pumps are being extensively used to lift water directly from the river for irrigation. Rice and other field crops are the main crops grown by river lift irrigation in the head and middle regions of the basin. In the tail-end areas vegetable cultivation is the dominant activity.

Farmers identified sedimentation and silting of tank beds, reduction of inflow into the tanks due to blocking of natural watercourses by encroachers, and unplanned development activities in the tank catchments as some of the major hazards in the basin. Unregulated sand mining carried out on a large scale was reported as the major cause of environmental degradation in the Deduru Oya basin. It is the biggest commercial activity in the basin. Excessive sand mining has resulted in seawater intrusion, loss of natural ponds along the river and reductions in the groundwater level, and in disturbing the stability of bridges across the river.

East Rapti

Agriculture is the major source of livelihood of the population in the basin. Of the total economically active population of the Makawanpur district, 83 percent is involved in agriculture, slightly more than the national percentage. In Chitwan, 75 percent of the population is engaged in agriculture. It is estimated that about 26 percent of the total land area in the basin is used for agriculture. Of the total area cultivated, some 18 percent is in the river valleys and inner plains. These are the major irrigated farming areas in the basin. The cropping intensity (CI) of these areas is between 200 and 300 percent. Cropping patterns in such areas with year-round irrigation facilities are:

- Paddy-Fallow-Paddy
- Paddy-Wheat-Paddy
- Paddy-Wheat-Fallow
- Paddy-Legumes-Paddy
- Paddy-Legumes-Fallow

However, in areas with seasonal irrigation facilities, the cropping intensity approaches 200 percent. The cropping patterns in such areas are:

- Paddy-Wheat
- Paddy-Legume
- Paddy-Maize
- Maize-Oilseeds
- Maize-Maize
- Paddy-Vegetables
- Maize-Vegetables.

Livestock (improved breeds of buffaloes and cows) and poultry farming are also very popular in the plains. The hilly areas of the basin are largely rain-fed. The dominant cropping patterns in these hilly areas are:

- Maize-Millet
- Potato-Millet
- Maize-Potato-Fallow
- Maize-Fallow

Nearly 75 percent of the holdings are smaller than 1 hectare each. Landownership in the basin is highly skewed. About 46 percent of the householders own only 16 percent of the total available cultivable land, whereas some 6 percent of the householders own approximately 26 percent of the total cultivable land.

A significant development over the last few years is the proliferation of groundwater development, particularly in the plains. A major reason for the rapid spread of groundwater development is the subsidy amounting to 60 percent of the cost for the establishment of tube wells. More recently, the government has suspended the subsidy program. This has slowed down the establishment of tube wells.

Fuyang Basin

Fuyang is one of the most water-short basins in North China. The availability of per capita water resources is less than 400 m^3. Agriculture is the largest user of water. The share of agricultural water has been declining over time, from 81 percent in 1993 to 75 percent in 1998. This is primarily due to growing domestic demand. Industrial water demand during the same period has increased by only 1 percent.

The total design area under surface irrigation is about 43,000 hectares. The actual irrigated area is substantially less than the designed area. In the 1990s, the actual area irrigated was only 41 percent of the designed irrigated area. Most of the surface irrigation systems are managed by government agencies, though a contract management system was implemented in some periods. With the decline in surface-water supply and increasing demand for water for agriculture and domestic and industrial uses, groundwater exploitation increased rapidly.

Groundwater irrigation investment was mainly financed by the local villages and townships, with varying extents of government-financed subsidies. Prior to the implementation of the household production responsibility system (HRS) initiated in the late 1970s, investment in groundwater was by local government agencies with financial assistance from higher levels of the government. Farmers contributed family labor for constructing groundwater irrigation systems. These systems were under collective ownership. With the implementation of HRS, investment in groundwater was primarily by private individuals.

There is evidence that groundwater tables (both shallow and deep) have fallen by more than 1 m annually in the past two decades. Urbanization, industry and population growth have also led to increasing surface water and groundwater pollution, which have further aggravated the water-scarcity problem in the basin.

The main crops under irrigation include wheat, corn, cotton, rice and some millet, soybean, peanut, and horticultural crops. With the modernization of agriculture since the 1950s, crop yields have increased. Yield of grain crops has doubled. Over the same period, the yield of ginned cotton has increased threefold.

Ombilin River Basin

The main use of water varies among the three major rivers and lakes that constitute the basin. In the Ombilin river, water is used for irrigation, industry, power generation and domestic water supply. Irrigation and domestic water supply are the dominant uses of water in the other two basins.

The development of the Singkarak Hydroelectric Power Plant, which transfers water into another basin, significantly reduced the outflow of water from the Singkarak lake to the Ombilin river. The reduced water flow in the Ombilin river has adversely affected farmers who rely on the river for irrigation water. Pump irrigation has been adopted by a very limited number of farmers in the last decade.

Marked seasonal fluctuations in the river flow are a major feature of the Ombilin river. For the owners and operators of waterwheels, fluctuations in the water discharge of the Ombilin river have caused several problems in system operation and maintenance (O&M). The inadequate and unreliable supply of irrigation water has adversely affected agricultural production in the basin. Rice yield has declined from an average of 4.2 tons per hectare earlier to 3.1 tons per hectare in 1999. Water quality is an emerging problem. This is mainly due to the discharge of effluent from a coal plant. Fish populations in the river has declined due to the deterioration of water quality. This has affected cash incomes of householders dependent on fishing for their livelihood.

Some Institutional Arrangements in the Selected Basins

Management of Water Resources

In all five countries where the case studies were conducted, there is an explicit recognition of the importance of considering the river basin as the unit for developing and managing water resources. Yet none of the river basins studied were managed by a formal river-basin

organization. The management of water resources in the basins was purely on sectoral lines by a multiplicity of government agencies with little interagency coordination.

In China, four major laws and some 30 state regulations provide the institutional framework for managing the country's water resources. The current laws and regulations concern water management, finance, water pricing, water withdrawal permit system, water saving and irrigation district management. Steps are being taken to formulate legislation to strengthen integrated watershed management, water allocation and efficiency issues within and across major river basins (Center for Chinese Agricultural Policy 2000).

In principle, water allocation in the Fuyang river basin should be done by the Hebei Province Water Resources Bureau in coordination with five prefectures within the basin. In practice, the bureau has very limited power in allocating water among prefectures and counties in the basin.

In West Sumatra, Indonesia, where water management is fragmented between several government agencies, a provincial water management committee (PTPA) was set up to coordinate the activities of the various agencies. Basin-level committees are also supposed to be set up. However, up until now no such committee has been formed in any of the six river basins located in the West Sumatra Province.

In the Upper Pampanga basin, several government agencies are tasked with the administration of water in the basin. Their interests and functions are administrative and regulatory in nature. Despite the presence of these agencies within the basin, it is still beset with problems and issues such as siltation of waterways, land conversion, water pollution and lack of a coordinating body to promote effective water-resources management in the basin. The situation is the same in Deduru Oya, where some 20 sectoral departments and agencies are involved with the administration and management of water-resources. East Rapti is no exception, with a multiplicity of agencies involved in water management. There have been recent attempts to make district- and village-development councils responsible for coordinating activities at the local level. They have not been very effective, partly because such functions were considered to be the responsibility of central line agencies and partly due to limited local capabilities.

In all basins, attempts have been made to foster greater farmer participation in O&M of irrigation systems. China has introduced far-reaching institutional reforms in the groundwater sector with decollectivization of the groundwater systems and transferring them to private ownership and management. The management of surface irrigation systems has been vested with the local government authorities. In the other locations, lift irrigation systems, both river lift and groundwater systems, are managed by individual owners, except in Nepal where the larger systems are managed by water user associations (WUAs). The larger surface irrigation systems are under joint WUA-agency management. In Sri Lanka, however, the minor schemes are managed by farmer organizations.

Water Rights

Deduru Oya. Water rights in the basin come within the purview of national statutes relating to water. The Crown Land Ordinance of 1949 gives a person who occupies the land on the bank of any public lake or stream the right to use water in that lake or stream for domestic use, and livestock or agricultural purposes provided that it is extracted by manual means. The owners of private lands can extract groundwater in their lands without any restrictions. There are no

rules or regulations to control their water use. Water rights relating to irrigation are clearer. In old irrigation schemes, such as the small tanks in old villages in Sri Lanka, water rights are defined traditionally. However, the tank, irrigation canal system and the catchment area are entirely government property. In new schemes, the allottees have equal rights over water. Under water-scarcity conditions, the proprietors can take decisions on which part of the irrigation system is entitled to water in a given season, at a cultivation meeting held for that purpose.

East Rapti. In Nepal, the Water Resources Act of 1992 and its bylaws in 1993 vested the ownership of all the water resources in the country with the government. A government license is required for the development of the water resources other than those on the land of a landowner. However, the development of water for individual and collective use for drinking and irrigation does not require a license. Water rights in Nepal are available to people in the following four ways (Kayastha et al. 2001):

- natural right for developing water for a limited purpose
- right acquired through license for developing water resources for a specific purpose
- upper riparian has prior right compared to the lower riparian
- customary use right and prior appropriation right

Fuyang river basin. According to the Water Law of China, there are two kinds of water rights related to surface water and groundwater:

- Collective property rights—if a reservoir or a water body belongs to a rural collective organization, property rights to water stored in these reservoirs and water pockets will also belong to the collective.
- State property—all other water bodies, both surface water and groundwater, belong to the state.

According to the regulations on water-withdrawal permits, users (including individuals and institutions) cannot draw water from any river, lake or groundwater resource without obtaining a water-use license. The water-resources management agencies at each level have the right to issue a license to the water user. At present, water trading or transferring the water withdrawal permit or the water use right is prohibited. In the event of any violations, the water-resources administration or any other relevant authority can revoke the water-withdrawal permit and expropriate unlawful income.

Ombilin. According to the Indonesian constitution, water is a god-granted resource and should be used for the highest level of welfare of the people. Therefore, water is owned communally by all citizens. No individual ownership can be claimed over water. This idea also provides the basis for the state right to control—but not to own—water. This state right to control water is exercised by the government. The legal framework exists to issue licenses granting use rights, but such licenses have not yet been issued for water use in the Ombilin subbasin.

Upper Pampanga. In the Philippines, the utilization of surface water and groundwater is governed by the Philippine Water Code through the National Water Resources Board (NWRB). All the water belongs to the state and is not subject to any acquisitive prescription. The State may allow the use or development of water by administrative concession through the issuance of a water right to a user. The water right is the privilege to appropriate and use water granted by the government through the NWRB. The measure and limit of appropriation of water are beneficial use as well as the utilization of the right amount during the period that the water is needed for producing the benefits. Priorities in appropriation of water follow the priority in time principle, except in times of emergency when the use of water for domestic purposes has a superior right to other uses.

A Comparative Perspective on the Five River Basins

Commonality in the Five Basin Studies

1. Explicit recognition of the importance of IWRM.
2. Explicit recognition of the river basin as the unit of management of water resources.
3. Growing scarcity of water and inter-sectoral competition for water.
4. In some countries, water for domestic use and industry is given priority over allocations for agriculture.
5. The need for a clearer definition of water rights.
6. Groundwater is emerging as an important source of water. Given this trend, groundwater management is becoming an important issue.
7. Water-quality issues and committing water for environmental purposes are major issues.

Major Problems in the Respective Basins and Proposed Solutions

Table 2 provides a checklist of problems as reported in various studies. There are four problems common to all five sites: a) need for reliable data, b) inadequate planning, c) absence of well-defined water rights, and d) absence of mechanisms for integration of the development and use of surface water and groundwater. Other problems tend to vary from site to site although water inadequacy in the dry season is common to all sites. The site-specific problems and proposed solutions are highlighted in the following paragraphs.

Deduru Oya

Problems

- Inadequate surface water and groundwater resources in the middle reaches of the system coupled with high incidence of poverty.

Table 2. List of problems reported in the case studies

Issues	Basin				
	East Rapti Ombilin	Singkarak Pampanga	Upper	Deduru Oya	Fuyang
A. Basin-Level Issues					
Need for reliable data and information management	✓	✓	✓	✓	✓
Inadequacy or absence of basin-level planning procedures	✓	✓	✓	✓	✓
Absence of well-defined water rights and allocation principles	✓	✓	✓	✓	✓
Absence of institutional mechanism to integrate surface water and groundwater resources development and use	✓	✓	✓	✓	✓
Watershed degradation and surface water and groundwater pollution	✓				✓
Absence of river-control measures				✓	
B. Sector-Level Issues					
Water inadequacy during dry season	✓		✓	✓	✓
Head-tail differences			✓	✓	
Groundwater decline					✓
Low productivity	✓			✓	
Inadequate water control			✓	✓	✓
Waterlogging and flooding			✓		

- Unregulated proliferation of wells and pumps lifting water from the river.
- Inadequate river flow at the tail end during the dry season, coupled with industrial development and shrimp farming, causing conflicts and environmental problems: destruction of mangrove swamps, seawater intrusion and groundwater contamination.
- Uncontrolled exploitation of river resources, e.g., sand mining, leading to lowering of the water table.

Solutions

- Creation of a river-basin management committee.
- Coordination of river-basin management and planning at the district, division and agrarian-services levels.

Fuyang

Problems

- With the basin becoming "closed" about 1980, shift to emphasis on groundwater development for agriculture.
- With agricultural reforms beginning in 1980s, shift toward privatization of groundwater.
- Depletion and overdraft of groundwater resources.

Solutions

- Strengthen enforcement of national water policy, laws and regulations.
- Promote market-oriented property rights management and innovation measures: rational water price, water markets and water-rights transfer.
- Implement a permit system for groundwater withdrawal.

East Rapti

Problems

- Adequate water resources but inadequate development of groundwater resources and management of water resources for conjunctive use.
- Need protection of water requirements for the Chitwan National Park and the buffer zone.

Solutions

- Develop a basin-level coordinating facility.
- Support shallow tube-well development to reduce farmers' dependence on river water.

- Review, establish and implement water rights among sectors.
- Strengthen and implement pollution-control standards.

Ombilin

Problems

- Rapid decline in water availability and reliability for agriculture due to the construction of a hydropower plant and the interbasin transfer of water.
- Nonexistance of an organization for river-basin management.
- Formal water use rights not implemented, not only due to gaps in regulations but also due to lack of data on which to make decisions.
- Need for low-cost technology for lift irrigation to replace waterwheels whose performance has been impaired by reduced flows.

Solutions

- Short term—establish water allocation rules and release more water to the basin.
- Short term—improved technology for lifting water.
- Long term—develop a Brantas river-type basin-management body.
- Long term—review and strengthen water laws, rights and regulations.

Upper Pampanga

Problems

- Adequate water, but more storage facilities and water-conservation measures along with conjunctive use of groundwater are needed to reduce temporal and spatial shortages of water in the basin.
- Rapid decline in O&M budgets coupled with government decision on complete irrigation-management transfer.
- Growing deterioration of the quality of surface water due to increased industrial and municipal pollutants.

Solutions

- Form a river-basin coordinating council.
- Strict enforcement of existing laws, regulations and policies on pricing, allocation and water quality.
- Strengthen and enhance irrigation association capacity for O&M.

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[2]This section is based on the report prepared by Makin et al. (2002).

Lessons from Case Studies on Advanced River-Basin Management

Three supplementary case studies of what were considered as advanced river-basin management were carried out with the aim of drawing lessons that might be useful for developing countries. Two of these were river basins from developed countries: Omanogawa basin in Japan, and Murray-Darling basin in Australia. The third was the management of the Brantas basin in Indonesia. The following paragraphs highlight some of the key features in these basins that might be useful inputs for designing management systems for river basins elsewhere.

Omanogawa

Omonogawa is well endowed with water resources.[2] Even in years of severe drought, such as 1994, a considerable volume of water was discharged by the river system. It is an urbanized basin, with an urban population of about 70 percent out of a total population of around 690,000. Agriculture is a secondary activity. The younger generation finds it less attractive as an occupation due to the limited income potential from agriculture compared to industry and the public and commercial sectors. The area under paddy cultivation has been reduced over the past 20 years as the impacts of reduced consumption took effect, as the nation became wealthier and reduced subsidies.

Omonogawa has a long history of over a thousand years of water development and management initiatives that originate from the water users, specifically farmers. In common with many countries, there are many institutions with interests in management of water resources. In Japan, the Ministry of Construction has the predominant role in river-basin development and management, a position that has been maintained for over a hundred years. Although the role of the public sector is central to water-resources management, farmer groups have a well-established role based on participatory development and management of natural resources for the protection of agricultural water resources. In recent times, numerous land improvement district (LID) schemes have been undertaken in the basin. The LID system is recognized as one of the more successful innovations in the region to support user involvement in management of irrigation and water-resources schemes. However, the LID system has grown out of long experience in communal management of land and water resources. This experience has included many years of bitter and painful conflict among farmers concerning water allocation. The prevailing system for water management has been developed gradually by farmers themselves, subsequently formalized by the Land Improvement Act, promulgated in 1949.

Individual LID management organizations are responsible for the daily operation, maintenance, and development of the irrigation and drainage systems. A noteworthy feature is that LIDs reinstated traditional forms of water distribution, originally superceded following construction of the main intake channel. The LIDs are also responsible for the quantitative measurement of water abstractions and also for water-quality measurements. The LIDs can

[3]This section is based on the report prepared by Young and McDonald (2001).

force municipalities or industrial users to construct and operate water-treatment plants if discharges are not within the approved standards.

Key Lessons from the Basin

1. Administration of a water-surplus basin does require positive management—to ensure drainage and flood-control structures are operated and maintained correctly. During times of drought, even in water-surplus basins, there needs to be a well-documented and effective system available to manage revision of water allocations to ensure that basin-scale impacts are minimized.

2. Water-quality issues can be dealt with effectively when the sectors involved are able to monitor and evaluate compliance of the other sectors.

3. Water-management agencies focused on agricultural water management, such as the LIDs in the Omonogawa basin, have a major role to play in the management of water resources. With appropriate delegated authority and support, these agencies can be highly effective.

4. The need to involve water users in making decisions.

5. The need to build on traditional institutional arrangements, which are time-tested and adapted to local conditions and needs.

The Murray Darling

The Murray-Darling river basin was chosen for study as it typifies a basin where the hydrological boundary extends over several administrative regions and the institutional arrangements are in place for effectively coordinating water-management functions in a large geographical area.[3] The basin is managed in a framework that involves the Commonwealth (or Federal) Government, four states, and one territory. The framework involves layers of representative bodies that consist of a Ministerial Council, the Murray Darling Basin Commission, and a series of high-level groups interspersed with community representatives. These layers make up the fora where strategies and policies are set out for sharing the water and managing the serious problems of water quality in the basin.

In Australia, water resources are largely under the jurisdiction of the state and territorial governments. The Federal Government participates in water and water-resources management through other means, such as legislative and executive capacity.

The Murray-Darling river basin is managed by individual states but there are overarching bodies that coordinate many of the efforts of state and territorial governments at the basin level. Rather than amending the Constitution, a Murray-Darling Basin Commission has been formed to manage inter-jurisdictional processes and conflicts in an organized manner. The Commission is the executive arm of the Murray-Darling Basin Ministerial Council that consists

[3]This section is a summary of the report of Sunaryo (2001).

of ministers responsible for land, water and environmental resources in each of the signatory or contracting governments. The Commission is an autonomous organization equally responsible to the governments represented on the Ministerial Council as well as to the council itself. The commission began with a mandate to manage water quantity that has gradually extended to include water-quality issues and, to a limited extent, related land-resources management issues. In the late 1980s, it was given a mandate to initiate, support and evaluate integrated natural resources management across the Murray-Darling basin.

Over the last decade or so, the Murray-Darling Basin Commission has become increasingly aware of the need for, and the benefits of, community consultation. To this end, in 1986 it established a Community Advisory Committee that reports directly to the Murray-Darling Basin Ministerial Council. Today, virtually all commission programs involve a large degree of consultation. Most policy reforms are, at the least, discussed with the council and explored through transparent media and meeting-based processes. Draft policies and strategies are then released and finalized after a period of time.

The lessons from the basin can be summarized largely in terms of how conflicts are managed. Managing resources sustainably has required innovative mechanisms to be put in place that will encourage reform in an environment of cooperative federalism.

The Murray-Darling Agreement is a prime example of institutional rules designed to manage conflicts. The myriad constellations of committees and groups of officials work reasonably well despite the complexity of the arrangements. The key is the continuities created by ministers and their deputies sitting on various committees. Trust between individuals has grown over the years. In these settings, moral suasion works as a mechanism to encourage states to act in a manner consistent with the common good.

Brantas River Basin

The Brantas river basin was selected for a case study as an example of a single organization (Jasa Tirta I Public Corporation) managing multiple uses of water in a large river basin in a developing country.[4] Jasa Tirta Public Corporation was established in 1990 to manage major water resources in the Brantas basin. The corporation also carries out conservation, development and utilization of the river and water sources, including giving information, recommendations, education and guidance. In 1999, the name of Perum Jasa Tirta was changed to Perum Jasa Tirta I.

The guiding principle of the organization is "one river, one plan and one integrated management." One river (basin) is a hydrological unit that covers several administrative areas managed as one unit. There should be one integrated, comprehensive, sustainable and environmentally based concept of a development and management plan. One management system should guarantee an integration of policies, strategies and programs as well as implementation of the system for all of its reaches. The scope of river-basin management covers watershed management, water-quantity management, water-quality management, flood-control management, river-environment management, water-resources infrastructure management, and research and development.

The management system adopted by the organization is based on the application of corporate principles. The organization engages in consultancy services as part of its resource mobilization strategy. Fees collected from water uses are an important source of finance. However, on the basis of political decisions, the agriculture sector—the largest user of water—is exempted from water fees (table 3). Public, private and community participations are

Table 3. The agricultural sector in the five river basins.

Characteristics	Fuyang (China)	Ombilin (Indonesia)	East Rapti (Nepal)	Upper Pampanga (Philippines)	Deduru Oya (Sri Lanka)
No. of surface irrigation schemes	3	184 (river lift)	214	37	3,600
No. of groundwater irrigation schemes	185,527	14	2,445	9	2,453
Surface irrigated area (ha)	150,000	32,180	32,388	98,222	47,150
Groundwater irrigated area (ha)	875,000	—	7,743	25,135	1,515
Main irrigated crops	Wheat, corn, cotton, rape-seed	Rice, mungbean, groundnut	Rice, maize, wheat	Rice, vegetables, corn, onion	Rice, chili vegetables
Annual cropping intensity (%)	155	na	na	156–surface 200–ground water	133-165%-surface 180-300–groundwater
Comparison of current crop yield with yield 10 years ago	Decline in yield of all major crops	No change in yield of major crops	No change in yield of major crops	Drop in rice yield by 14-21%	Current yields of major crops are higher
Reasons for yield change	Water scarcity, institutional constraints	Not relevant	Not relevant	Climatic changes, pest outbreak	Improved agronomy, better prices
Responsibility for O&M—groundwater systems	Individual farmer	—	WUAs	—	Smaller systems–WUAs; larger systems WUAs and Irrigation Agency
Responsibility for O&M—surface-irrigation system	Local government authority	River lift systems (waterwheels) – individual owners	WUAs and Irrigation agency	Irrigation Associations (WUAs) and Irrigation agency	Individual owners
Multiple use of irrigation water	Yes	Yes	Yes	Yes	Yes

considered important aspects of effective water-resources management. Stakeholders are involved at each decision-making level through coordination fora. Roles of the key stakeholders are defined as follows:

- The government, as the owner of the water resources and its infrastructure, plays the role of controlling and regulating at the national and regional level and exercising its public authority.
- The River Basin Management Agency is authorized to manage water resources and infrastructure, including receiving contributions and rendering water-resources services.
- Society acts as users that have the right to receive services and participate in decision making, but is expected to use water efficiently and take part in sustaining the environment.

Key Generic Lessons

- The study has shown that there are clear stages to river-basin development. The development responds to the changing pattern of demand for water over time, linked to population growth and economic development.
- There is a clear need to focus on improved data collection and transformation of these data into useful management information. This information needs to be broadly shared with stakeholders.
- There is an urgent need for clearly defined water rights. Without clear understandings about water rights and effective enforcement, the poor and disadvantaged groups are vulnerable to losing access to water.
- The lessons from the case study of advanced river-basin management (Japan and Australia) suggest that formal "river-basin organizations" are not an essential feature of successfully managed water-scarce river basins. Other arrangements, including various kinds of committees and networks, can often work just as effectively. But there needs to be a clear legal framework, including clarity on water rights, and a regulatory framework to make such arrangements work.
- There is a clear need to design effective mechanisms for stakeholder consultation and enlist their cooperation in implementing programs for developing and managing water resources. Well-designed stakeholder-driven institutions are more likely to have positive outcomes.
- The "success stories," Murray-Darling, Omonogawa and Brantas, suggest that institutional development has been a slow process taking decades. There is a clear need for more research on appropriate institutional arrangements and the sequence in which new arrangements should be introduced.

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