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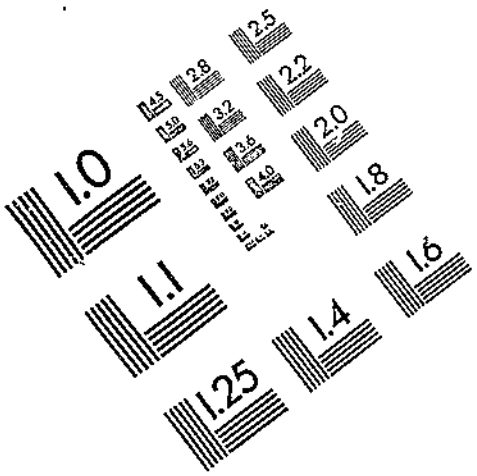

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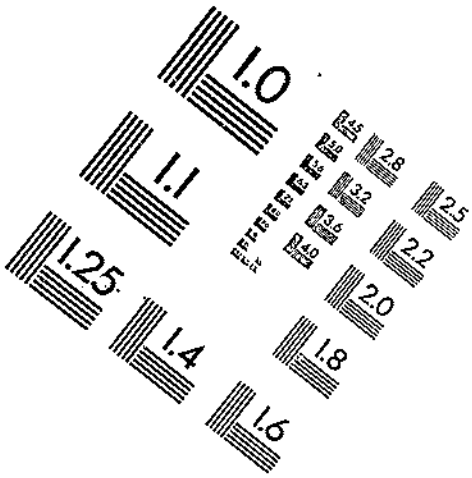

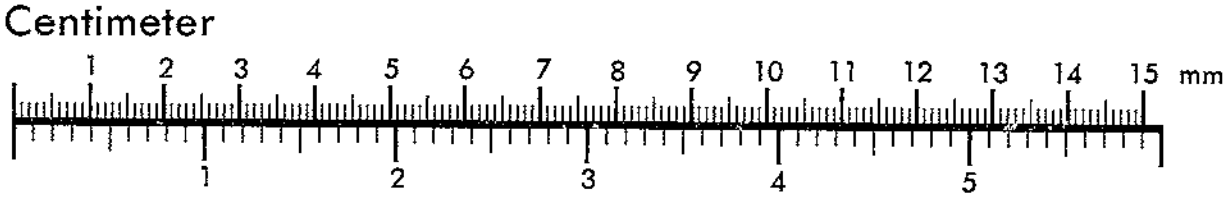

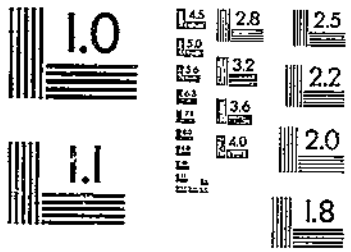

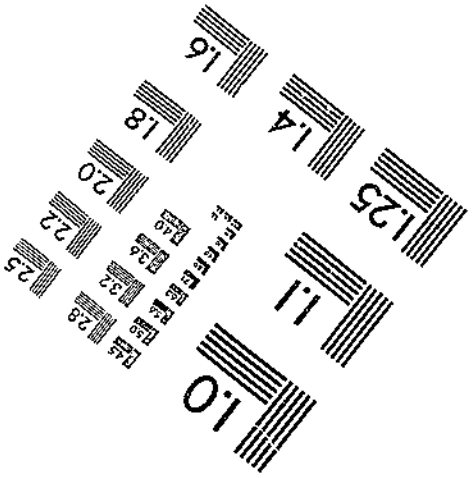

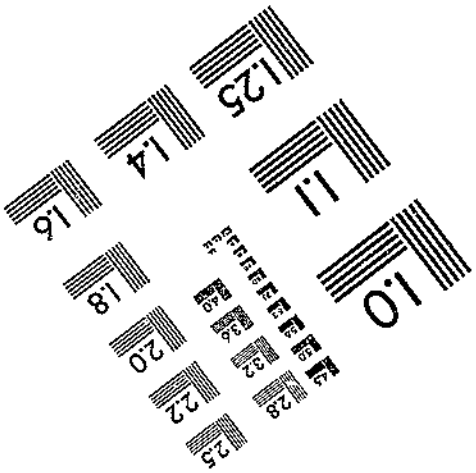

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Global Review of Resource and Environmental Policies Water Resource Development and Management

Economic Research Service, Washington, DC

Jun 94

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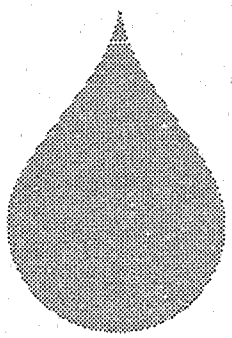
Water Resource Development and Management



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This report reviews how 30 countries develop and manage their water resources. Because the focus of the report is on agriculture, particular attention is given to irrigation. The study found that differing climatic conditions, demand for water, and historical situations led to diverse laws, policies, and administrative structures across countries.

Keywords: Argentina, Australia, Brazil, Canada, Chile, China, Denmark, Egypt, European Union, France, Germany, Hungary, India, Indonesia, Israel, Italy, Japan, Jordan, Kenya, Mexico, Netherlands, Nigeria, Pakistan, South Africa, Spain, Sudan, Thailand, Turkey, United Kingdom, United States, Zambia, water, irrigation, water rights, water policies, water pollution, water user associations, water management, salinization.

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This report is one of a series of reports under the project, Global Review of Resource and Environmental Policies. Other reports cover land, manufactured fertilizers and pesticides, and wildlife and natural areas. This project was initiated by Margot Anderson, Lon Cesal, Ken Forsythe, Denice Gray, Ann Hillberg-Seitzinger, Peter Liapis, Carl Mabbs-Zeno, Daniel Pick, Terri Raney, Jerry Sharples, and Shwu-Eng Webb. Carl Mabbs-Zeno and Denice Gray are the coordinators of the project. Denice Gray prepared the data sheets for each country with the assistance of Carol Stillwagon. Joseph Makuch, coordinator of the Water Quality Information Center at the USDA's National Agricultural Library, provided literature searches for this report.

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Contents

Preface

This report is one of a series of reports prepared under the project, Global Review of Resource and Environmental Policies. This project catalogues resource and environmental policies of various countries, with an emphasis on policies affecting agricultural production and trade. The project breaks policies into four categories: water, land, agricultural chemicals, and wildlife and natural areas.

ERS undertook the Global Review of Resource and Environmental Policies project because connections among agricultural production and trade, resource management, environmental quality, agricultural and trade policies, and environmental policies have increasingly confronted resource, environmental, and trade analysts. However, there was no general reference to foreign environmental policies. This project attempts to fill that void in the reference literature and is best used as a reference guide.

The strength of the Global Review of Resource and Environmental Policies project is in its breadth and consistency of coverage. The review systematically organizes information and allows cross-country comparisons. The four volumes of this project briefly describe, in lay terms, laws, policies, and administrative structures by country. No quantitative assessment links these resource management systems to environmental quality indicators or to competitiveness, nor is rigorous analysis conducted. Rather, this review introduces the reader to country policies and administrative structures. The volumes briefly mention the effects of various types of policies and structures on productivity, investment, and environmental quality if the evidence is clear-cut. Actual implementation, enforcement, and effectiveness of policies are also briefly detailed. Policies are organized according to the resource they most affect. For instance, policies with the goal of improved water quality that regulate fertilizer use will be described under agricultural chemicals.

Country coverage reflects several criteria. We sought to include the major U.S. trading partners, so that we can later analyze how their environmental policies might affect production and trade. We sought a balance of different kinds of countries: developing and developed, diverse climatic conditions, and differing resource constraints and demands on resources. Such a set of countries presents the variety of approaches to managing resources and confronting environmental problems. However, country coverage is not complete across all four volumes. In some countries, only one resource was of interest. Lack of data and rapidly changing conditions hindered coverage of other countries.

ERS is publishing the four volumes separately in print format. All information presented in the four volumes will also be available in an electronic format. As new information is received on country policies, we will update the electronic version of the publication.

Global Review of Resource and Environmental Policies

Water Resource Development and Management

Gary Vocke

Introduction

Agriculture is a large consumer of the world's fresh water, accounting for almost 70 percent of global withdrawals (World Resources Institute, 1992). How this water is managed influences agricultural production around the world and, hence, trade among countries. Water is a key input for crop and livestock production. About 20 percent of the world's cropland is irrigated, and this land produces 40 percent of the world's agricultural output (Kay, 1986).

Policies supporting the development of increased supplies of water to expand irrigation can increase agricultural yields and production. Policies to shift water from irrigation to higher valued urban and industry uses can reduce production. Policies allowing soils to become damaged by waterlogging or salinization can reduce yields and production. Some agricultural practices impair the quality of water; policies to manage these practices can also affect production costs. Such changes in production costs, yields, and total production affect a country's competitiveness in international markets and, thus, its agricultural trade.

This report first notes why countries manage water resources differently and then presents the range of choices through country examples. The 30 country profiles in the report were chosen to represent a wide range of governmental situations, economic development, climatic conditions, and water availabilities. In most countries, irrigation is the largest agricultural user of water (table 1). Exceptions occur, such as the United Kingdom where the dairy sector is the largest agricultural user of water.

The high percentage of water going to agriculture in some of the lower income countries reflects (1) the lack of industrial usage, (2) large proportions of their

Table 1--Annual water use by selected countries, 1992

Country	Agricultural withdrawals	Withdrawals for all uses	Agricultural withdrawals
	Percent of total	-- km^3 --	
Sudan	99	18.6	18.4
Pakistan	98	153.6	150.3
India	93	380.0	353.4
Thailand	90	31.9	28.7
Chile	89	16.8	15.0
Egypt	88	56.4	49.6
China	87	460.0	400.2
Mexico	86	54.2	46.6
Israel	79	1.9	1.5
Indonesia	76	16.6	12.6
Argentina	73	27.6	20.1
South Africa	67	9.2	6.2
Jordan	65	0.5	0.3
Kenya	62	1.1	0.7
Spain	62	45.3	28.1
Italy	59	56.2	33.2
Turkey	57	15.6	8.9
Nigeria	54	3.6	2.0
Japan	50	107.8	53.9
Denmark	43	1.5	0.6
United States	42	467.0	196.1
Brazil	40	35.0	14.0
Hungary	36	5.4	1.9
Netherlands	34	14.5	4.9
Australia	33	17.8	5.9
Zambia	26	0.4	0.1
Germany	19	50.4	9.6
France	15	40.0	6.0
Canada	8	42.2	3.4
United Kingdom	3	28.4	0.9

Source: World Resources Institute, 1992.

population bathing in and washing their clothes in streams and canals, (3) the scarcity of flush toilets, and (4) limited watering of urban lawns. In wealthier countries, much water is extracted for these purposes.

Reasons for Differences Across Countries

The amount and pattern of precipitation and relative availability of water have an important influence on the demand for water and a country's development and management of water resources. In many regions of the world, water is a limiting factor in agricultural production, and so, irrigation has been developed. Countries with rainfall concentrated at particular times of the year may need to construct dams to store water for later use.

Where water is scarce relative to demands, a water management system will have to be developed to allocate water among competing uses and users. Not only will the priority of users and uses for scarce water supplies vary from country to country, but the method of allocation will also vary. How this allocation is made will reflect the social and economic objectives established by each country's legal and political processes. A country's water management system may arise from several sources, including legislation, customary law, case law, and international agreements. Some countries rely on a government bureaucracy to allocate water resources and to change the allocation as conditions evolve with economic development. Other countries rely more on courts to carry out this function. In some countries, markets and prices are used to allocate the water among competing uses.

Systems of Water Management

Water is a mobile and renewable resource, except for some groundwater sources. Water flowing down a river has potential users all along its course, with upstream users having first chance to divert the water. Users of water, however, do not have to be next to the watercourse because water can be transported by canals or pipes. As long as demands are less than supply, there is no allocation problem. As soon as demands exceed supply, the society will need to develop a system of allocating water use rights among competing uses.

Water resources can be managed as a separate resource or in conjunction with land. Water supplies in some countries are handled as private property. In other countries, the water is public property, with the right to extract given by the state to users.

Management of Water Resource Allocation

Means of attaining water ownership or use rights will reflect public choices on priorities for the use of water. Priority of use is important given the uncertainty of rainfall and the possibility of drought leading to temporary water shortages. Societies use a wide range of legal and administrative systems for using water resources productively and for resolving competing claims for the resource. Few countries use markets and market-clearing prices to ration water supplies among users.

Some countries, usually those with abundant water supplies, give private water users considerable flexibility in deciding how water is to be used. In countries or areas with scarce water supplies relative to demands, there will likely be a public determination of priority uses and public controls on the users of water. Public control and flexibility to shift water to new uses is often accomplished through limited duration and specific use licenses, for example, a license to use a particular quantity of water for irrigation lasting 10 years. The development of these systems will also reflect whether the country is a federation of states (like the United States), with each state responsible for its own water resources, or is a unitary state (like Israel) with the central government taking responsibility for water.

In the United States, surface waters are a public resource and each State is allowed to develop its own legal and administrative system. The States initially followed one of two legal systems for surface waters: riparian or prior appropriation. In the humid, eastern half of the country and along the West Coast where water is abundant, the legal system that developed for surface waters provided all landowners bordering a stream an equal right to make a reasonable use of the water and to be safe from harm by others' making unreasonable use of the water. The right of use arises out of land ownership, but the landowner does not own the water in the stream. Courts determine whether or not a particular use is reasonable after disputes are brought before them. Thus, reasonable use is always subject to re-evaluation by the courts when circumstances change. This system is called the riparian rights system.

In the arid and semiarid western half of the United States, the States developed a legal system in which the earliest water user on a given watercourse has preference over later users. The right to use does not arise by land ownership, but by putting the water to a beneficial use. This system is called the prior appropriation rights system. An appropriative right to

a fixed amount of unappropriated water can be obtained if the water is diverted and put to beneficial use regardless of where the use is located. Generally, holders of an appropriative water right can make changes in the point of diversion or the place or purpose of use without loss of priority so long as there is no impairment of other water rights. If the appropriator fails to make use of the water for a period of time, the water right will be given to someone else. The prior appropriation system provides for a more secure right to water than the riparian system, especially for the early appropriators. This security is important if large waterworks investments like irrigation infrastructure are to be made.

Israel is a unitary state where the central government is directly involved in licensing water to urban, industrial, and agricultural users. Licenses are valid for 1 year and specify the quantities of water to be withdrawn and its use. The quantities and uses are transferable only with the permission of the Government.

Countries are often forced to change the way their water resources are allocated as they develop economically. Rising demands for water in the eastern United States, for example, have caused some States to replace riparian rights with regulatory permitting systems in order to limit excessive withdrawals. With a regulatory permitting system, administrative officials choose among competing users and ensure minimum water flows for fish and other public purposes.

Israel did not always have its water licensing system. In 1959, Israel passed the Water Law, which refuted existing private water rights that were based on previous Ottoman and British law. Water sources were made public property under the control of the Government. The Ministry of Agriculture was made responsible for allocating water supplies to urban, industrial, and agricultural users through a licensing system. This system of temporary licenses allows the Government to carry out its current objective of taking fresh water from irrigated agriculture to supply the rising needs of residential and industrial users. The Government will increase the supply of treated, urban waste water to agriculture to substitute for this loss of fresh water.

Some countries allow private individuals to reallocate water usage through markets. For example, in Chile, all water resources are national property and the Government grants individuals and entities water use rights. These water rights become private assets that can be bought and sold.

Countries often have a different legal and administrative system for groundwater than the system for surface water. In the United States, for example, there are four basic groundwater systems: absolute ownership, reasonable use, correlative rights, and prior appropriation. Under absolute ownership, overlying landowners can withdraw any quantity of water from beneath their land for any use without liability for harm to their neighbors. Reasonable use doctrine recognizes the rights of adjacent landowners to a limited extent; the extracted water must be for a reasonable use, as decided by the courts. Under the correlative rights system, the landowner's use must not deprive adjoining landowners of their fair share of the groundwater, even for a reasonable use. This system permits an overlying landowner to petition the court to decide the water rights of all users. The court prorates allowable extractions among overlying landowners based on its safe yield. Thus, the courts have a larger task under this system than under the reasonable use system. The prior appropriation system allows withdrawal of groundwater for a beneficial use after obtaining government approval. The administrative official must determine if unappropriated groundwater exists and evaluate any adverse effects before approving the application to extract water.

In the United States, each State can decide what court system to use for adjudicating disputes between water users or between water users and the State. Colorado, for example, has a specialized Water Court that handles water disputes. Other States use the same court system as the one used for nonwater issues. In Israel, the public can go to the Tribunal for Water Affairs, a special court that takes appeals from the public against orders issued by the Government. Some countries have a specialized legal system just for irrigation. For example, the user associations for irrigation systems in Spain each have an irrigation jury. The jury members are elected by those in the association. Judgments are oral, public, and immediately enforced.

User Organizations for Irrigation Schemes

Surface water irrigation schemes with expensive waterworks for diverting water from rivers or for supplying water from storage dams are typically constructed by the State. The main waterworks infrastructure usually remains under the control of the government. Coordination in supplying water among irrigators and maintaining the smaller canals is often

handled differently. In some countries, the government has responsibility for these functions. In other countries, user organizations manage and maintain the system.

In India, irrigation is developed and managed by the Government. Almost half of the country's irrigated area receives water from sources directly under government control. In most cases, the Government provides for the construction of the facilities up to the field outlets. There is no nationwide procedure of allocating this water to farmers in public irrigation systems and the irrigators have little say in how the schemes are run. In northern India, farmers typically expect to receive canal water in proportion to their land holdings in the system. In middle and southern India, irrigation water is rationed annually by the government bureaucracy based on a cropping pattern also determined by the Government.

In the United States, the States can create special water districts to manage irrigation. Districts are legal entities separate from the State government. Districts are favored in several ways so they can obtain funds for constructing waterworks. They can assess levies, issue bonds that are exempt from Federal income taxes, and raise revenue through water charges. District services can include delivery of water for nonagricultural uses, as well as the generation and sale of electricity. District board members are usually elected, but districts vary in their procedures for selecting their governing boards. The right to vote for board members may, for example, be with each voter in the district, or with each landowner, or may be weighted according to landholding.

Incidence of Benefits and Costs

Water development in most countries is usually a mix of public and private efforts. The public activity often leads to subsidies to water users. Many countries, for example, have developed public irrigation schemes to promote economic development of a region. Because these schemes are viewed as development efforts, the price of the water charged to the irrigators is often much less than the public expenditures to build and operate the irrigation systems.

Water bodies are sometimes polluted when they are used for waste disposal. Livestock manure when handled improperly, for example, is sometimes a source of excessive nutrients that degrade the quality of the water for other users. When pollution occurs, countries have several options if the degradation is to be controlled. Mandatory controls on the polluter can be imposed. The government can then decide to what extent compensatory payments will be used to offset any expenses or lost income incurred by the polluter when complying with the controls. Voluntary programs are also a possible controlling mechanism, but financial incentives are typically required to ensure compliance.

Irrigation Development and Sustainability

The United States used subsidized irrigation development to promote regional economic development in the West, mainly through large surface water irrigation schemes. There has also been substantial private irrigation development in the United States, especially groundwater development in the western plains.

Irrigation development in other countries is also often a mix of public and private activities. In Brazil, for example, most of the irrigation has been developed by the private sector for growing high-value crops, which can easily pay for the investment for irrigation. However, in the country's relatively poor, semiarid Northeast, where there are only limited local markets for high-value crops, the Government has developed subsidized public sector irrigation schemes to promote economic development.

In Chile, irrigation is also controlled mostly by the private sector and it is the country's policy that any new irrigation development should originate in the private sector. However, Chile encourages private irrigation investments with a subsidy program that will reimburse up to 75 percent of private investment in construction and rehabilitation of suitable projects.

Besides deciding the extent to which irrigators will be subsidized, government-developed schemes face choices about irrigation drainage. An irrigation scheme without a drainage system is cheaper to construct, but presents a greater risk of damage to the land by waterlogging and salinization. In Egypt, for example, a significant proportion of the agricultural land is reportedly affected by salinity problems. Much of this salinization occurred because a drainage system was not constructed when the High Aswan Dam allowed the change to perennial irrigation from the traditional flood irrigation that had been practiced for thousands of years. These salinity problems have reduced yields, and in some cases caused abandonment of the land. A drainage system is now under development to stop the salinization process and to recover lost and damaged land.

Protecting Water from Pollution

The U.S. Federal Government has been given responsibility for protecting surface water from point sources of pollution. States have responsibility for nonpoint sources of surface water pollution and for protecting groundwater from pollution. This Federal/State relationship can be illustrated by the example of manure from livestock operations. The size of the livestock operation determines whether it will be treated as a point source of pollution and whether it is eligible to receive a subsidy for constructing waste handling facilities. Operations large enough to be point sources of pollution are required to construct facilities for waste handling and are not eligible for financial assistance to construct these facilities. The Federal Government has a two-part classification scheme. Livestock operations with more than 1,000 animal units are classified as point sources of pollution, as are operations greater than 300 units that discharge pollutants directly into navigable waters.

Operations smaller than 1,000 units that do not discharge into navigable waters are considered nonpoint sources of pollution. Nonpoint source pollution is defined by the Federal Government as pollution caused by diffuse sources that are not regulated as point sources. Only the States have the authority to require these operations to construct facilities for controlling livestock waste pollution.

The Federal program providing subsidies to farmers to construct animal-waste storage facilities is voluntary and is provided only to livestock operations that are not required by law to construct such facilities.

The European Union (EU) has also had to deal with pollution from livestock wastes. Whereas the United States imposes pollution abatement on all operations above a certain size, the EU approach has focused on the quality of the water itself. The EU has legislated the maximum allowable nitrate content of water supplies in member countries. Each country is then to enact legislation to achieve this water quality standard.

In the Netherlands, surplus manure is taxed. Surplus manure is manure produced on a farm in excess of what can be recycled on the farm's land for crop production without risk of nitrates leaching into the groundwater. Farmers are required to pay for the cost of transporting the surplus manure to land elsewhere in the country for disposal.

The Dutch Government is constructing plants to process this surplus manure into fertilizer pellets that can be sold elsewhere, usually at a financial loss. The construction and operation of these processing facilities are partially financed by the levy that farmers pay on their excess manure production and by a levy on feed manufacturers. The goal of this manure processing is not to make a profit, but to ensure the survival of the livestock sector.

The United Kingdom (UK) has enacted new legislation allowing the creation of Nitrate Sensitive Areas (NSA's) in which farming practices can be regulated to reduce nitrate pollution of water supplies. NSA's are areas where water is already polluted by nitrates or vulnerable to nitrate pollution. The farmers in designated NSA's will have to comply with the Code of Good Agricultural Practice for the Protection of Water. Only a few areas have been identified as NSA's. Complying with the Code will still be voluntary outside these identified areas.

The UK Government has regulations enforcing good practices for storage of manure. Failure to comply with these regulations for newly constructed or reconstructed facilities is an offense. The Government provides grants to farmers for constructing or improving manure storage facilities. Thus, the taxpayer is covering part of the cost of preventing water pollution.

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Argentina

An 1884 law provides the legal framework for the government to administer the use of water in Argentina. Both surface flows and groundwater are part of the public domain, except where the entire course lies within the land of a single owner. These public domain waters are the responsibility of Provincial governments. A river or stream flowing through two or more Provinces is also subject to national legislation.

Irrigation Development

About two-thirds of the country is arid or semiarid. In these regions, irrigation is a valuable supplement to rainfall. Ninety percent of the water used for irrigating is surface water.

Provincial administrative systems for managing water for irrigation vary widely. In some Provinces, the water resources are administered by a central agency. This agency will store water in dams and deliver it to the farmers. In other Provinces, the Provincial government decides the water use policy and then lets local water users' associations manage the canals and participate in the preparation of the budget to operate the system and to build basic waterworks.

A Provincial Example of Irrigation Management - Mendoza

The Province of Mendoza, with one-third of the country's irrigated area, is a decentralized administration. Two independent provincial agencies, the General Irrigation Department (GID) and the Watercourse Inspectorate (WI), control the Province's water and its management. GID has ultimate control of the Province's water supply, diversion structures, and main canals. The WI is responsible for the secondary irrigation network.

The legal use of public surface water in Mendoza requires a GID concession for a specific amount. This concession of surface water rights is nontransferable. Within agriculture, the concession is assigned to a specific piece of land. If this supply of surface water is insufficient, the farmer can make up the shortfall by extracting groundwater. However, before drilling an irrigation well, the 1967 Civil Code requires the farmer to publicly describe the project to give third parties an opportunity to consider its effects and make objections.

The WI works with water user associations to manage the secondary and field canal systems. Mendoza has Provincial legislation defining these associations. Each association is administered by an inspector elected by the users. The inspector is a water judge in charge of settling water allocation questions. The inspector also administers the irrigation system's budget for operation and maintenance and for minor improvements.

The GID and WI finance themselves through a water charge. These water charges are fixed annually by the user associations and should cover the full costs of the irrigation works plus GID's and WI's administrative costs. The individual user's charge is determined by the quantity of water specified in the farmer's water concession and the length of the canals leading to his land.

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Authors: Julie Hopenfeld and Gary Vocke

Demographics

Population	32.9 million (1992)
Population growth rate	1.1% per year (1992)
Population density	12 per square km (1992)
Urban population	86% of total population (1990)
Urban growth rate	1.8% per year (1980-90)

Economics

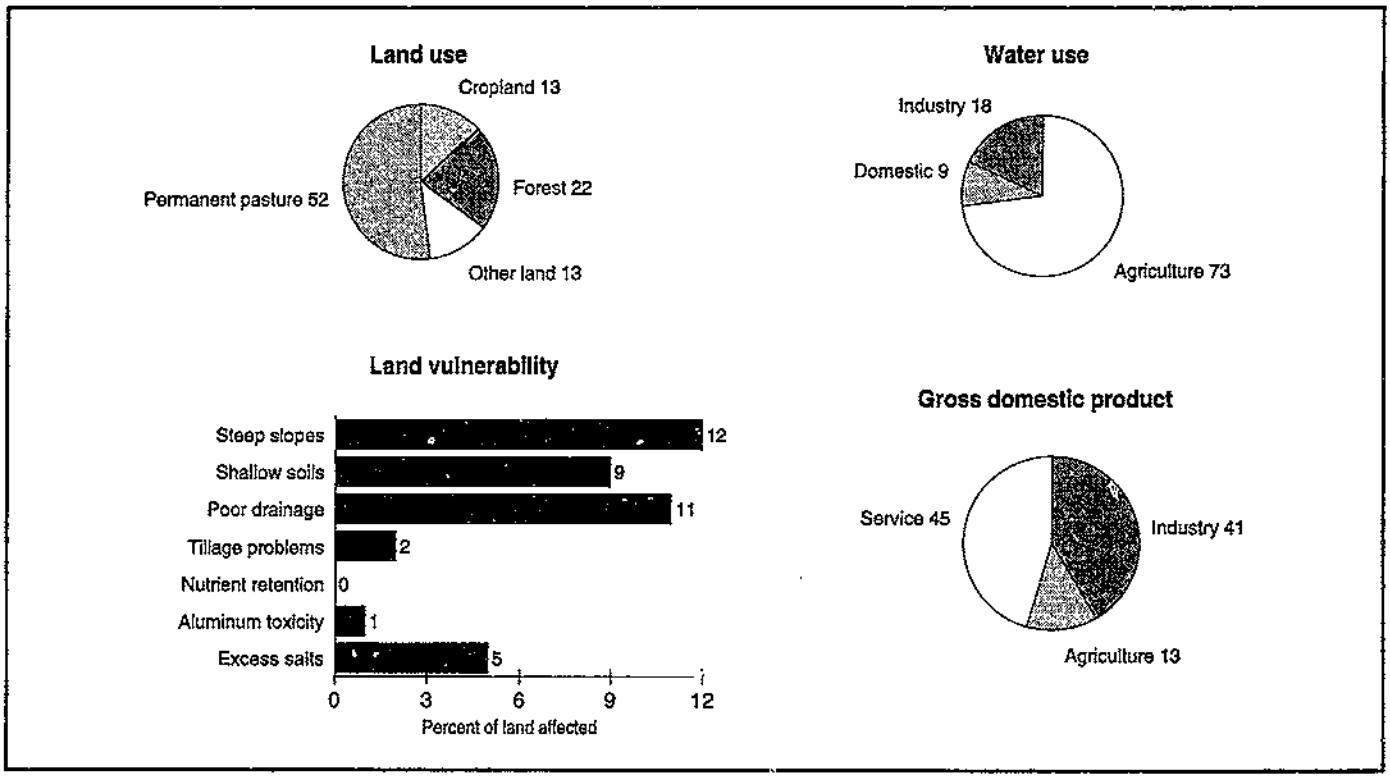
Gross domestic product	$93,260 million (1990)
GDP growth rate	-0.4% per year (1980-90)
GDP per capita	$2,887 (1990)
Total external debt	61.7% of GNP (1990)

Environment

Land area	2,736,690 square km
Irrigated land	5% of cropland (1987-89)
Average fertilizer use	5 kg/ha cropland (1987-89)
Average pesticide use	14,313 metric tons active ingredient (1982-84)
Livestock contribution to methane	2,900,000 metric tons (1989)
Wet rice contribution to methane	16,000 metric tons (1989)
Greenhouse gas emissions	154 million tons CO_2 equivalent
Greenhouse gas emissions per capita	4.9 tons CO_2 equivalent
Land protected	4.6% of total land (1990)
Number of known threatened animal species	84 (1990)

Climate: mostly temperate; arid in southeast; subantarctic in southwest.

Environmental problems: Tucuman and Mendoza areas in Andes subject to earthquakes; pamperos are violent windstorms that can strike Pampas and northeast; irrigated soil degradation; desertification; air and water pollution in Buenos Aires; waste disposal; soil erosion.



Australia

During Australia's colonial period, water use law was based on the British riparian rights system. Under this early Australian system, landowners with property adjoining watercourses had the right to maintenance of natural flow and coequal right with other riparian owners to make reasonable uses of water. This system was too limiting for irrigation development because it prohibited significant diversions of water to supply water-short areas elsewhere. This limitation on agricultural development prompted the passing of legislation allowing the needed diversion of water for irrigation.

Water Legislation

In 1901, Australia was organized into six States and two territories. The States then individually enacted legislation declaring public ownership of water use rights and establishing licensing systems for these water use rights. The States typically left the riparian owners only the right to withdraw water for domestic and stock-watering purposes. All other diversions had to be licensed by a State agency.

These State agencies make the right to withdraw water dependent upon the availability of surface water or groundwater supplies. There is no priority of old licenses over new licenses. Renewals are not automatic. These agencies usually have the power to grant nonriparian owners the right to acquire access to water by condemnation.

There is some Federal legislation for coordinating water management, especially for water quality protection. The Federal Government is responsible for water management in the territories.

Public Management of Irrigation Schemes

Agriculture is the nation's largest user of water and most of this is for irrigation. About 85 percent of the water for irrigation is from surface water sources. At present, an increasing proportion of the nation's total investment in the water sector is being used to correct deficiencies in existing projects because potential sites for new water projects are increasingly scarce. Consequently, the use of groundwater is increasing.

In State-run irrigation schemes, a public agency will allocate water to farmers based on some criterion, for example, the area and crop to be irrigated. Additional water beyond the allotment can sometimes be purchased when excess water is available, but usually for a higher unit price than the allotment. The States have administrative procedures to deal with water shortages. In some cases, all allotments are reduced proportionally. In others, high-value perennial crops have priority over other crops. Some States allow the sale of water allotments between farmers and between agricultural and nonagricultural uses.

Usually, the agency is expected to cover the cost of operation and maintenance of the public irrigation system with revenue from the sale of water. The irrigation charges do not cover the capital costs. Consequently, charges for irrigation water may be only one-tenth as much as urban users are charged. There is now increasing competition among water users and uses and agriculture's percentage share of the country's water use is expected to decline.

Where there is irrigation from a private diversion of stream flow or by private pumping of groundwater, a public agency may license the extraction. Usually, the agency responsible for administering the use and development of surface water is also responsible for administering groundwater. If the water supply is adequate, the license could be for unlimited water extraction in perpetuity. In cases where extraction has become excessive, the users may be required to renew their license annually to allow the agency the option to limit the amount of water that can be extracted. In some areas, there is no requirement for the licensing of groundwater extraction.

The Evolving Case of Victoria

States are changing their management of water resources. Victoria, for example, has historically allocated water to irrigators with the objective of encouraging the settlement of rural areas. Now, however, efficient use of water is being promoted through marketing of water rights among irrigators and auctioning off new supplies of water to the highest bidders.

Irrigation districts are provided water from State-constructed facilities. Water is made available for the cost of operating and maintaining diversion and distribution facilities. Within irrigation districts, irrigators have water rights based on their individual land area suitable for irrigation. The irrigators pay a fixed quantity charge for their water right whether they use it or not. In 1989, the State made these water rights tradable between irrigators in the district.

Water is also allocated to individuals outside of irrigation districts using licenses and permits. Licenses are normally given on waterways that have storage facilities. These licenses last for 15 years. These private diverters pay annual charges to reimburse any operation costs of the State. Capital costs are not covered. Permits are granted for waterways without any regulation and must be renewed annually.

When additional water supplies of a recently completed dam became available, the rights to divert the water were auctioned off by the Victoria Government to the highest bidders. This was the first time the State used an auction to allocate water supplies. The bidders were limited to individuals with legal access to the river.

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Authors: Jac C. Heckelman and Gary Vocke

Demographics

Population	17.6 million (1992)
Population growth rate	1.4% per year (1992)
Population density	2 per square km (1992)
Urban population	86% of total population (1990)
Urban growth rate	1.5% per year (1980-90)

Economics

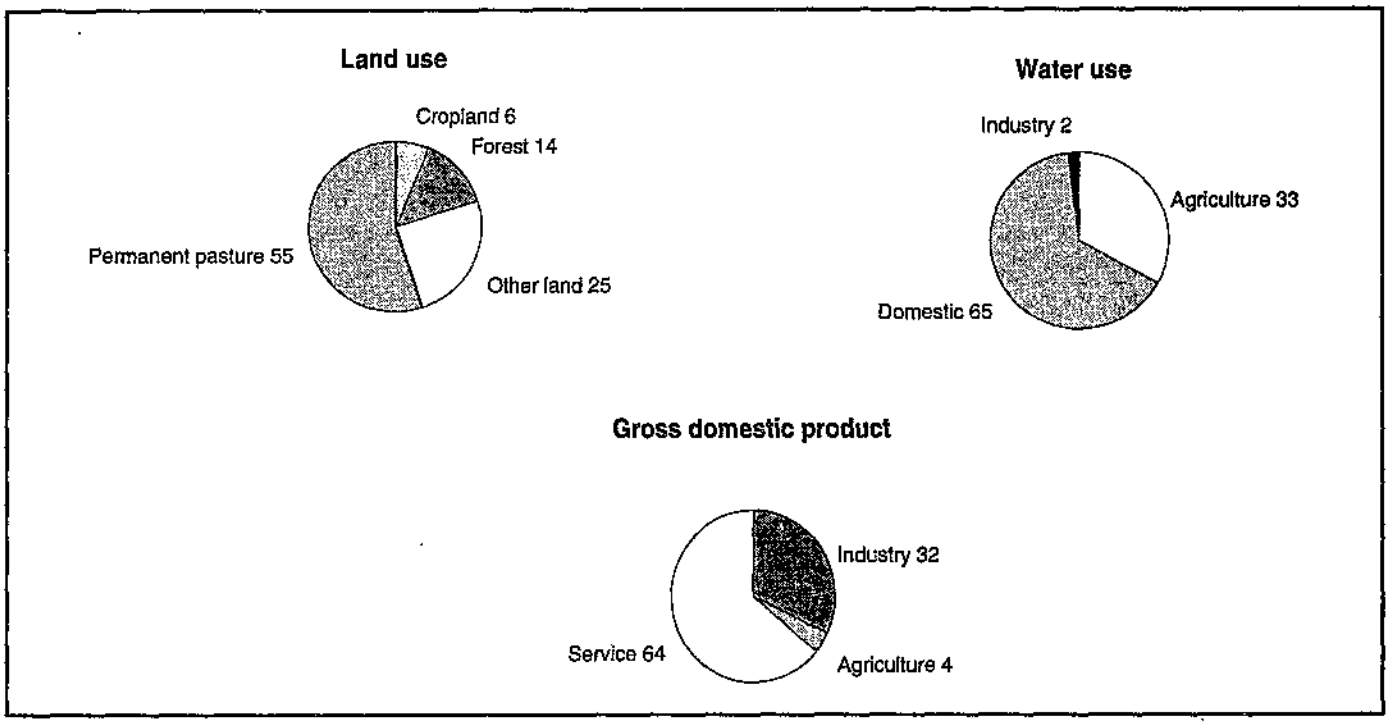
Gross domestic product	$296,300 million (1990)
GDP growth rate	3.4% per year (1980-90)
GDP per capita	$17,327 (1990)

Environment

Land area	7,617,930 square km
Irrigated land	4% of cropland (1987-89)
Average fertilizer use	26 kg/ha cropland (1987-89)
Average pesticide use	65,200 metric tons active ingredient (1982-84)
Livestock contribution to methane	2,000,000 metric tons (1989)
Wet rice contribution to methane	68,000 metric tons (1989)
Greenhouse gas emissions	313 million tons CO_2 equivalent
Greenhouse gas emissions per capita	18.9 tons CO_2 equivalent
Land protected	5.9% of total land (1990)
Number of known threatened animal species	102 (1990)

Climate: generally arid to semiarid; temperate in south and east; tropical in north; regular, tropical, invigorating sea breeze known as the doctor occurs along west coast in summer.

Environmental problems: subject to severe droughts and floods; cyclones along coast; limited fresh-water availability; irrigated soil degradation; desertification; endangered species.



Brazil

All water is the property of the government. Brazil's Constitution and Water Code distinguish between federally controlled and State-controlled public surface waters. Federally controlled surface waters are those bodies of water crossing State boundaries. All other surface waters are State property. All groundwater is the property of the States.

Government Approval Required for Significant Water Use

The country's Water Code requires that government approval be given for significant use of public water for agricultural, industrial, or sanitation purposes. Government authorization is waived if a negligible volume of water is used.

Management of the country's water resources is divided among several government agencies. The Ministry of Infrastructure is responsible for monitoring rivers under Federal jurisdiction and authorizing all water uses except irrigation, which is under the Ministry of Agriculture and Agrarian Reform, and drinking water and sanitation, which is with the Ministry of Social Welfare.

There is a legal and institutional framework for protecting environmental quality, but compliance is low because of a lack of enforcement.

Most Irrigation Development Is by the Private Sector

Brazil has only 3 percent of its cultivated area under irrigation. Although small, this irrigated area produces about 25 percent of the total farmgate value of agricultural production because irrigated lands are usually planted to high-value crops. Ninety-five percent of Brazil's irrigation development has been by the private sector with only a little government assistance through credit programs and construction of supporting infrastructure.

The exception to this policy of private sector irrigation development is in the semiarid northeast. The northeast is relatively poor so there are only limited regional markets for the high-value crops that pay for irrigation infrastructure. In addition, the relative scarcity of water resources raises irrigation infrastructure costs because of the need for an extensive canal system. For these reasons, the Government has developed public sector irrigation schemes in the northeast region. The Government usually provides all irrigation infrastructure in these projects down to, and including, onfarm works. When a project becomes operational, the responsibility for operation and maintenance and for the collection of water charges is gradually turned over to farmer organizations.

Irrigation Law No. 6672 provides for cost recovery of the Government's irrigation infrastructure investment (excluding interest costs) and operation and maintenance costs through water charges. In practice, however, the rate of collection of water charges ranges from 50 to 90 percent.

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Economic Commission for Latin America and the Caribbean (1991). *The Administration of Water Resources in Latin America and the Caribbean.* United Nations.

Authors: Julie Hopenfeld and Gary Vocke

Demographics

Population	158.2 million (1992)
Population growth rate	1.8% per year (1992)
Population density	19 per square km (1992)
Urban population	75% of total population (1990)
Urban growth rate	3.4% per year (1980-90)

Economics

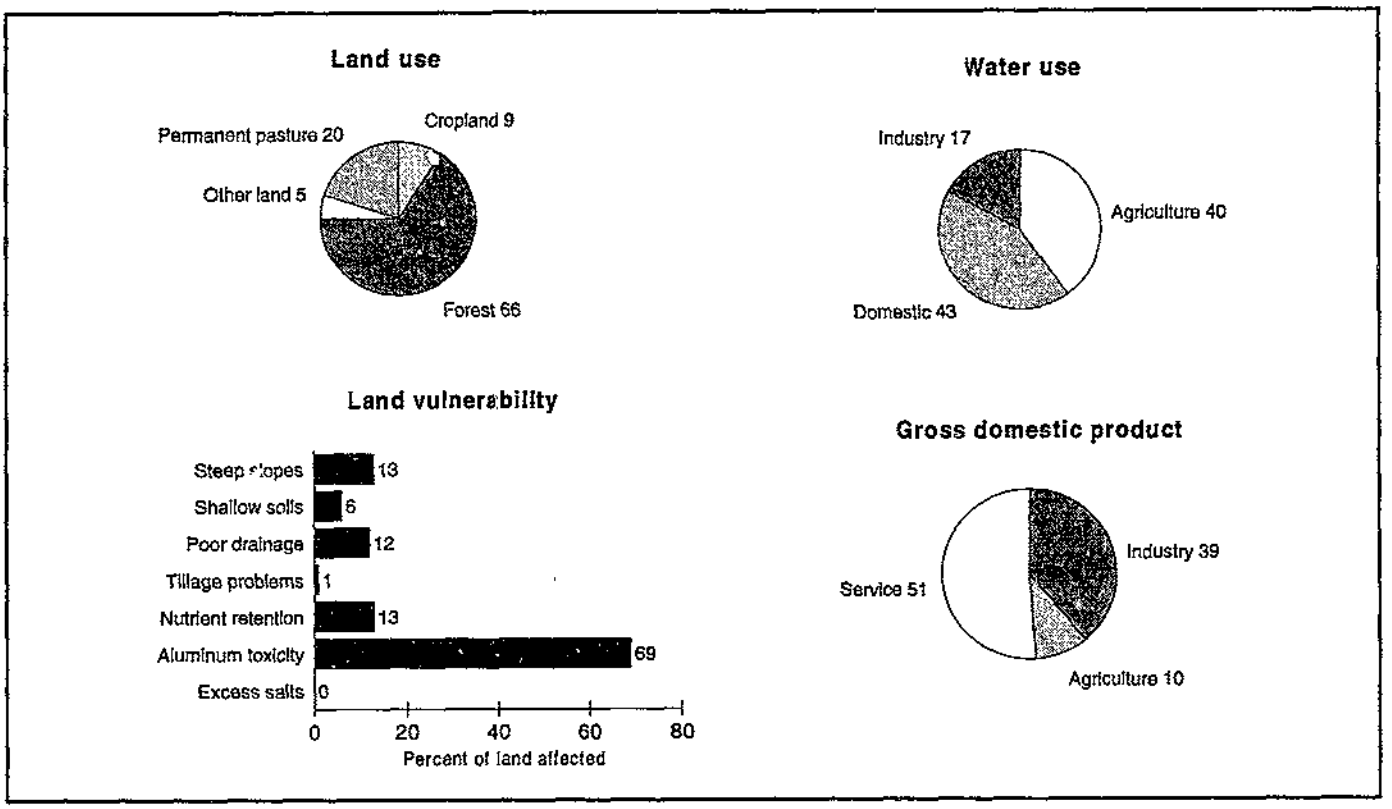
Gross domestic product	$414,060 million (1990)
GDP growth rate	2.7% per year (1980-90)
GDP per capita	$2,753 (1990)
Total external debt	25.1% of GNP (1990)

Environment

Land area	8,456,510 square km
Irrigated land	3% of cropland (1987-89)
Average fertilizer use	46 kg/ha cropland (1987-89)
Average pesticide use	46,698 metric tons active ingredient (1982-84)
Livestock contribution to methane	7,700,000 metric tons (1989)
Wet rice contribution to methane	430,000 metric tons (1989)
Greenhouse gas emissions	1,720 million tons CO_2 equivalent
Greenhouse gas emissions per capita	11.9 tons CO_2 equivalent
Land protected	2.4% of total land (1990)
Number of known threatened animal species	167 (1990)

Climate: mostly tropical, but temperate in south.

Environmental problems: recurrent droughts in northeast; floods and frost in south; deforestation in Amazon basin; air and water pollution in Rio de Janeiro and Sao Paulo; land degradation.



Canada

The legal framework for water management is based on the British North America Act of 1867. Under this Act, the Provinces own the water resources and administer their use. The laws governing water use vary from Province to Province. The Federal Government, however, is responsible for enforcing water pollution control regulations and for laying down the national effluent standards for certain sectors of industry. The Ministry of the Environment is responsible for coordinating all activities regarding water at the national level.

Large rivers are overseen by river basin agencies, which have the authority to levy pollution charges and to use this revenue for water quality conservation and improvement measures. These basin agencies have both Federal and Provincial representatives. The Provinces and the river basin agencies may set their own effluent standards, provided they are at least as strict as Federal standards.

To limit agricultural pollution, some Provinces restrict farming activities on lands bordering rivers and lakes. These restrictions include fencing off narrow strips of land and planting trees to stabilize stream banks.

Three Water Laws

Canadian water legislation was initially based on 19th century British legislation that regulated water use through riparian rights. This riparian system has now evolved into three systems of water law. In the humid eastern part of the country, the Provinces have developed riparian/permitting law systems. In the semiarid western Provinces where most of the irrigation occurs, a prior allocation law system is used. In northern territories, there is a Federal authority-management law system.

Riparian/Permitting Law

In the east, where water supplies were abundant relative to demands, a riparian law system was initially used to allocate water to users. Under this riparian system, water use rights were restricted to those who owned property adjoining a body of water. This system did not grant riparian owners a secure right to a particular quantity of water because a riparian landowner's right is dependent upon the extent of development that has taken place along the water body. As withdrawals increase with development, there is less and less water remaining for the original riparian users. In response to this rising demand with economic development, Provinces developed permitting systems for allocating water-use rights to new users.

There are variations in the permitting systems from Province to Province. The permits for these new users are usually for 5 years and are given on a first-come, first-served basis as long as there is an available supply of water. The water rights of the older, riparian water users remain as they were before the permitting systems were legislated. In times of shortage, conflicts between permit holders are settled by administrative discretion.

Prior Allocation Law

In the water-scarce west, the Provincial governments have developed a system called prior allocation that licenses water use rights on a first-come, first-served basis. When the available water supply is exhausted, no new licenses are given. Initially, these rights were given for an indefinite period. Now, some Provinces only grant rights for a specific term, usually sufficiently long to protect the licensee's investment. The earliest licensee is entitled to receive the entire amount stipulated in the license before the next licensee can receive any water at all.

Usually, licensed water-use rights can be cancelled only if a licensee has done something in violation of the license. Generally, the transfer of water rights apart from the land or undertaking for which the license was issued is not allowed. Existing water rights can be obtained by acquiring the land of an existing licensee and by continuing to use the water in accordance with the terms of the original license. In British Columbia, however, an industrial user can obtain in a voluntary sale the water rights of an irrigation farmer, without the necessity of buying the land or of using the water at the same location as the original licensee.

Federal Authority-Management Law

In the Northern Territories, which are under Federal management, the Northern Inland Waters Act gives the bulk of the legislative authority to the Federal Department of Indian Affairs and Northern Development. Under this Act certain powers go to Territorial water boards. These water boards are supposed to grant licenses based on statutory priority of use. In contrast to the prior allocation system, the applicant must show the water board that (1) the proposed use will not adversely affect an existing licensee with a higher statutory priority of use, and

(2) the applicant has compensated or will compensate any existing licensees whose use of water has a lower statutory priority and who will be adversely affected by the applicant's project.

These water licenses are granted for 25 years. The licenses cannot be transferred. In times of shortage, the allocation is by statutory priority. Within a management area, a licensee whose use holds a higher priority can consume his or her entire licensed allocation before any use by a person who holds a license for lesser priority use.

Policy Has Favored Irrigation Development

Agricultural withdrawals are only a small percentage of water withdrawals in Canada. Much of the water used by agriculture is for irrigation, mostly in the semiarid Provinces of Alberta and Saskatchewan. Irrigation development and rehabilitation is heavily subsidized. Both the Federal and Provincial governments provide financial and technical assistance for developing and maintaining irrigation schemes. The level of Provincial assistance varies among Provinces. Individuals can also generally receive assistance for developing an irrigation project, but not for maintenance.

Irrigation schemes are managed by boards elected from the irrigators. These boards are authorized through Provincial legislation and are responsible for setting the scheme's water charge for the irrigators.

Each Province can set its own water pricing policy. Some Provinces do not charge for water used by agriculture. In other Provinces, there is a service charge for delivering water to the farmer based on volume delivered or on the area of land irrigated.

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Authors: Rachel Wallace and Gary Vocke

Demographics

Population	27.4 million (1992)
Population growth rate	1.3% per year (1992)
Population density	3 per square km (1992)
Urban population	77% of total population (1990)
Urban growth rate	1.1% per year (1980-90)

Economics

Gross domestic product	$570,150 million (1990)
GDP growth rate	3.4% per year (1980-90)
GDP per capita	$21,515 (1990)

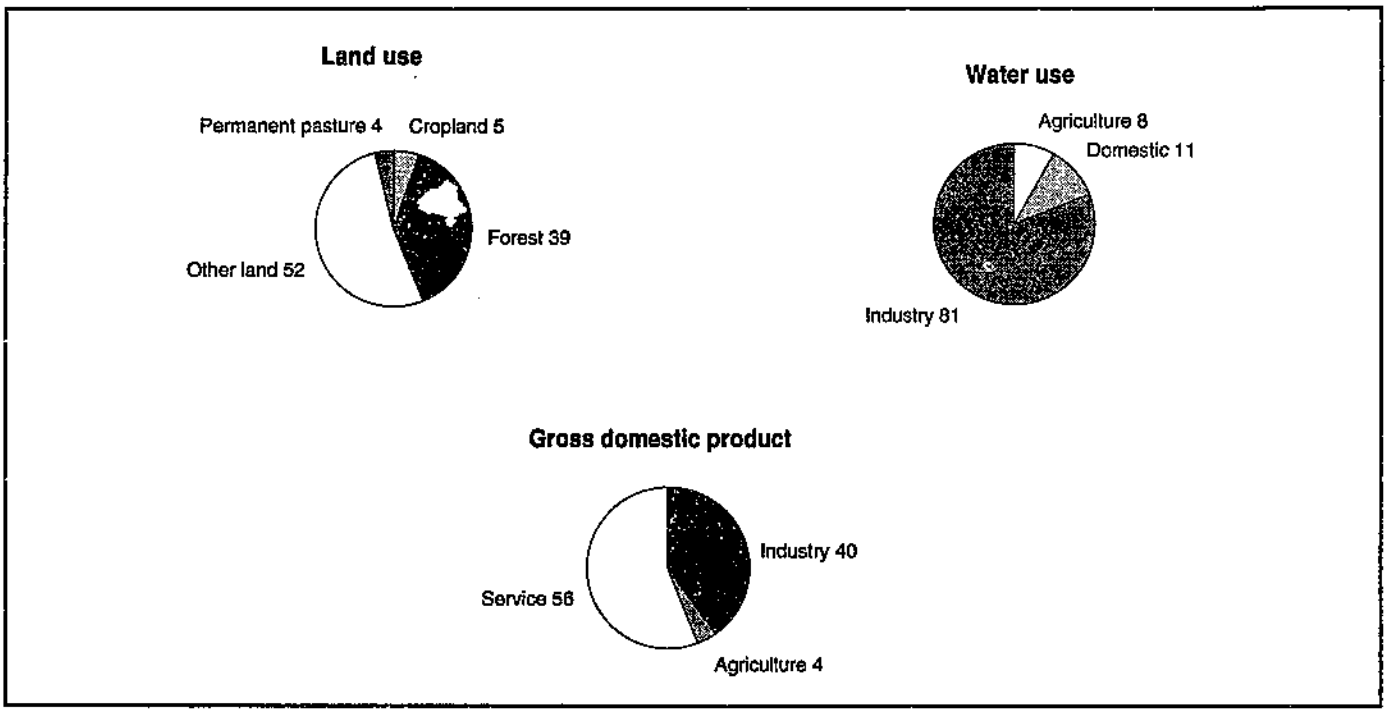
Environment

Land area	9,220,970 square km
Irrigated land	2% of cropland (1987-89)
Average fertilizer use	47 kg/ha cropland (1987-89)
Average pesticide use	54,767 metric tons active ingredient (1982-84)
Livestock contribution to methane	740,000 metric tons (1989)
Wet rice contribution to methane	NA
Greenhouse gas emissions	491 million tons CO_2 equivalent
Greenhouse gas emissions per capita	18.8 tons CO_2 equivalent
Land protected	5.0% of total land (1990)
Number of known threatened animal species	26 (1990)

Climate: varies from temperate in south to subarctic and arctic in north.

Environmental problems: 80% of population concentrated within 160 km of U.S. border; continuous permafrost in north a serious obstacle to development; acid rain; marine habitat degradation.

NA = Not available/applicable.



Chile

Chile's water legislation specifies that all water resources are national property. The Department of Water Resources of the Ministry of Public Works is the sole administrative authority in water matters. Its functions include granting individuals and entities water rights, establishing priorities for water rights, and maintaining a registry of all water rights concessions. The Water Code also provides for a National Water Authority (NWA) to solve most conflicts concerning water. Those conflicts the NWA is unable to resolve go to the courts for settlement.

The water right is a private asset separate from land that can be sold within and between agricultural and nonagricultural sectors. These water right transfers require prior authorization by the local water user association and the NWA. A water right can be mortgaged by itself, independently of the land.

Irrigation Development

About 28 percent of the cropped area of Chile is irrigated, mostly with surface water. The country's irrigation is controlled by the private sector and it is current policy that any new irrigation development should be by the private sector. The Irrigation Development Law encourages private investment in irrigation and drainage works through a subsidy program that will reimburse up to 75 percent of private investment in construction and rehabilitation expenses. The projects proposed for reimbursement cannot exceed US $250,000. Eligible projects are ranked by the National Irrigation Commission and the highest ranked projects receive the reimbursement funds.

Although the Government has not started any large-scale publicly funded irrigation projects since 1970, there is a law governing construction of irrigation and drainage works using public funds. This legislation, Law 1123, requires that before the Government proceed, at least 33 percent of the owners of land or water rights involved approve the project. Before construction of irrigation infrastructure can begin, beneficiaries representing at least 50 percent of the newly available water rights must commit themselves to reimburse the Government. The Government has the right to allocate any uncommitted, newly created water rights by competitive bidding. The Government operates and maintains the facilities for up to 4 years. Thereafter, water user organizations assume full responsibility for undertaking and fully funding operation and maintenance.

Irrigators are Being Given More Responsibility

Both the Government and the private sector administer irrigation works. Most systems are operated by associations of water users. The Government's Ministry of Public Works retains management responsibility for some schemes that are considered of special public significance. The local associations of water users are governed by elected boards of directors. These associations have the right to charge a tariff to meet the costs of operation, and in times of drought, to restrict the right to use water and redistribute the supply among users. These associations also can have a legal status that allows their members, collectively, to take out loans for waterworks.

Water watch committees, in turn, are responsible for administering the water user associations included in large irrigation projects. The water watch committees are also governed by elected directors.

The voting for the directors of water user associations and water watch committees is in proportion to the water rights held by the individual user. The law assigns to these user organizations the responsibility for regulating and administering the water resources and related infrastructure. Most irrigation and drainage works, including dams and reservoirs, are owned by users' organizations. These water user organizations are represented at the national level by the Confederation of Irrigation Canal Users Association.

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Lee, Terence R. (1990). *Water Resources Management in Latin America and the Caribbean.* Westview Press. Boulder, CO.

Authors: Julie Hopenfeld and Gary Vocke

Demographics

Population	13.5 million (1992)
Population growth rate	1.6% per year (1992)
Population density	18 per square km (1992)
Urban population	86% of total population (1990)
Urban growth rate	2.3% per year (1980-90)

Economics

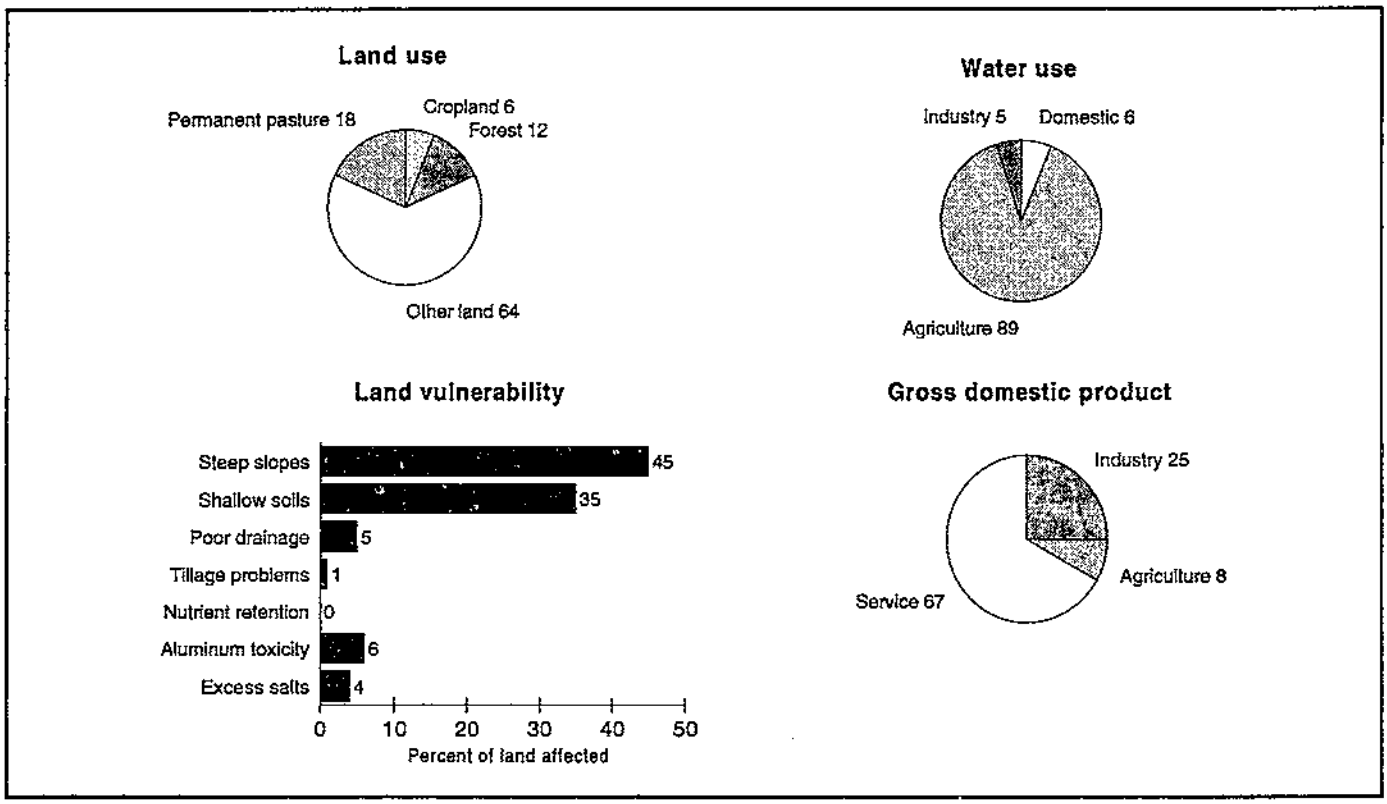
Gross domestic product	$27,790 million (1990)
GDP growth rate	3.2% per year (1980-90)
GDP per capita	$2,105 (1990)
Total external debt	73.5% of GNP (1990)

Environment

Land area	748,800 square km
Irrigated land	28% of cropland (1987-89)
Average fertilizer use	73 kg/ha cropland (1987-89)
Average pesticide use	1,800 metric tons active ingredient (1982-84)
Livestock contribution to methane	170,000 metric tons (1989)
Wet rice contribution to methane	8,000 metric tons (1989)
Greenhouse gas emissions	30 million tons CO_2 equivalent
Greenhouse gas emissions per capita	2.3 tons CO_2 equivalent
Land protected	18.0% of total land (1990)
Number of known threatened animal species	28 (1990)

Climate: temperate; desert in north; cool and damp in south.

Environmental problems: subject to severe earthquakes, active volcanism and tsunamis; Atacama Desert one of the world's driest regions; desertification; water pollution; urban pollution; overfishing.



China

The geographical distribution of water resources and the extent of their development is very uneven in China. In eastern and northeastern China, the demand for water in relation to supply is critical. In the south, there is relatively high rainfall and plentiful surface water, so the region uses a relatively small proportion of potential supply. Since the establishment of the People's Republic of China in 1949, water development has been through centralized planning. Now, however, because of the relaxation of centralized planning in recent years, some lower-level governmental units can develop and manage water resources, including water for irrigation.

Central Planning for Water Resources

The Constitution establishes that water resources are owned by the State. Since the establishment of the People's Republic of China, the development of the country's resources has been through centralized planning. The basic enabling legislation is the Water Law of the People's Republic of China. Chinese irrigation facilities, aside from very small ponds, dikes, and simple wells owned by individuals, belong to the public sector.

The State Council has made the Ministry of Water Resources the focal point for centralized water resources planning. This centralized system for water resource development and management is hierarchical, from the central government through the Provinces and further subdivisions (which include large collectives).

Irrigation Development and Management

All large irrigation schemes are national properties and are administered by the Ministry of Water Resources through irrigation districts. In the large irrigation projects, the Government is responsible for constructing the main canals and structures, with farmers contributing most of the labor. Farmers are responsible for constructing the tertiary canals and on-farm works. All materials are provided by the Government.

Small irrigation works are generally owned and operated by a local collective of farmers. Before construction, these irrigation projects must receive government approval. After approval, loans are usually available to finance the construction of the project. Sometimes the Government will provide subsidized building materials.

The management options for these small-scale schemes under the collectives are expanded under recent legislation. The service delivery functions can be leased or sold outright to contracting water management organizations. Such contracting entities can be companies, groups, households, or individuals. The contract manager agrees in the contract to perform specified functions. The contracting establishes a budget and a procedure for fee collection. The contract manager takes responsibility for profit or loss.

On both large- and small-scale irrigation schemes, system maintenance is largely from the compulsory labor still required of the rural population. All village residents can be required to provide labor, not just those families working irrigated land.

Financial Reform Within the Water Sector

The Government is pressuring the irrigation schemes to cover all of their operation and maintenance expenses. The Government is also changing its policies for financing of large-scale water infrastructure construction, for the pricing of water to users, and for the handling of the water fees that are collected.

The increased emphasis on financial self-reliance of schemes has led irrigation schemes to develop secondary enterprises to generate income. These secondary activities include the sale of hydropower, supplying of water to cities, and fish farming from reservoirs.

Irrigation policy reforms include the change in financing of the construction of large-scale water infrastructure in 1985. The new policy requires repayment of capital advanced by National and Provincial governments that were previously provided as a grant. This change contributed to a slowdown of new irrigation construction in recent years.

Water pricing policy is also being changed. The State Council has issued a new set of regulations concerning water charges. Charges to agriculture and domestic users are to reflect the cost of supply, including operation and maintenance costs and facility depreciation. Charges to industrial users should include an additional fee to provide a profit to the supplier.

Finally, the handling of water fees is being changed. In the past, the fees collected went into general government revenue budgets. Now, fees are kept for the system's budget. New water laws forbid use of water fees for uses other than operation and maintenance of the system from which the fees were collected.

North China Plain Water Development

The North China Plain is an important agricultural region, with a high population density, large cities, and industries. Now, the region's water resources are almost fully developed and potential water shortages threaten continued economic development.

The history of water resource development on the North China Plain can be divided into three phases. During the 1950's and 1960's, the emphasis was on increasing the supply of surface water. Most of the Plain's large reservoirs were constructed during this period.

The second period was the development of groundwater resources through to the early 1980's. The use of both surface water from a canal and groundwater from a well has made it possible to supplement the rotational canal supply with on-demand supply from the well.

Since the early 1980's, the emphasis has been on improving water management because the groundwater resources of the region are nearly developed. In large areas of the Plain, groundwater levels are dropping because of overexploitation. This overexploitation has prompted discussion of a long-term solution: transferring water from the South, where water supplies are abundant, to the Plain.

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Authors: Jac C. Heckelman and Gary Vocke

Demographics

Population	1,169.6 million (1992)
Population growth rate	1.6% per year (1992)
Population density	125 per square km (1992)
Urban population	56% of total population (1990)
Urban growth rate	NA

Economics

Gross domestic product	$364,900 million (1990)
GDP growth rate	9.5% per year (1980-90)
GDP per capita	$322 (1990)
Total external debt	14.4% of GNP (1990)

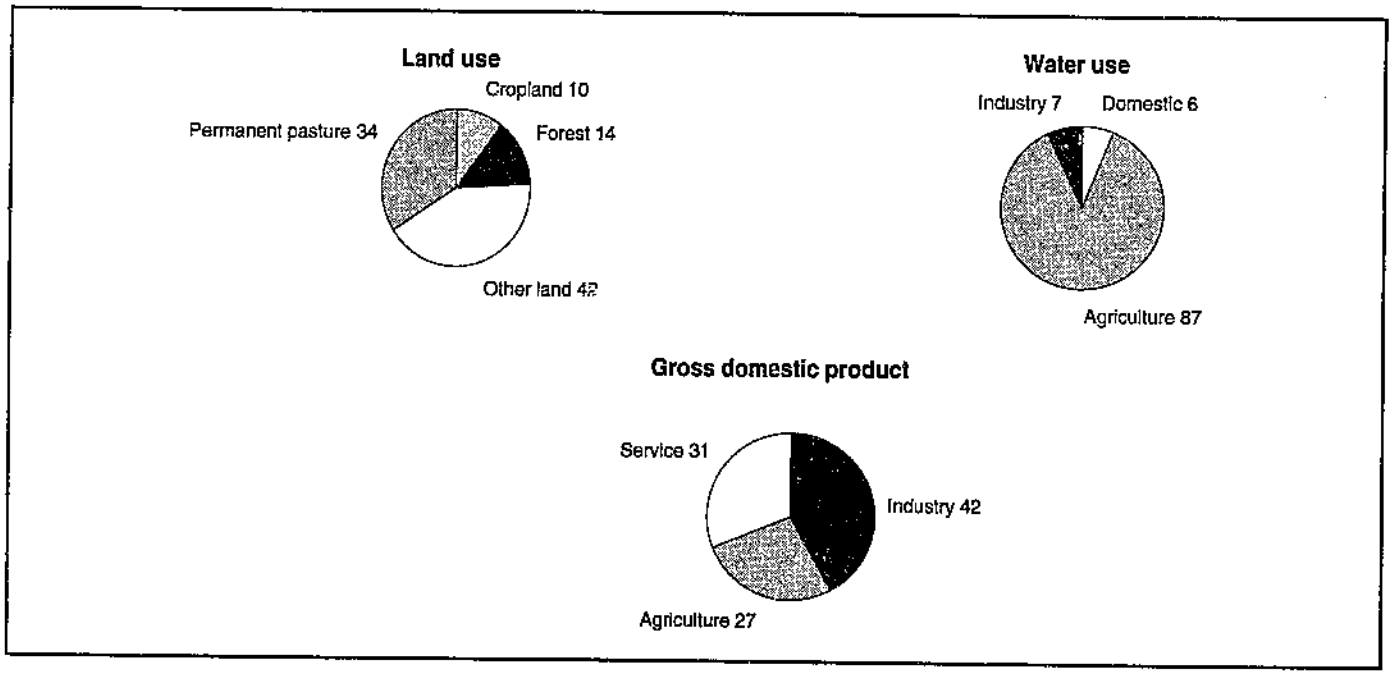
Environment

Land area	9,326,410 square km
Irrigated land	47% of cropland (1987-89)
Average fertilizer use	255 kg/ha cropland (1987-89)
Average pesticide use	159,267 metric tons active ingredient (1982-84)
Livestock contribution to methane	5,300,000 metric tons (1989)
Wet rice contribution to methane	19,000,000 metric tons (1989)
Greenhouse gas emissions	2,337 million tons CO_2 equivalent
Greenhouse gas emissions per capita	2.2 tons CO_2 equivalent
Land protected	2.3% of total land (1990)
Number of known threatened animal species	128 (1990)

Climate: extremely diverse; tropical in south to subarctic in north.

Environmental problems: frequent typhoons (about 5 per year along southern and eastern coasts), damaging floods, tsunamis, earthquakes; deforestation; soil erosion; industrial pollution; air and water pollution; desertification.

NA = Not available/applicable.



Denmark

The Water Supply Act and the Environmental Protection Act establish the legal framework for managing the country's water resources. The Minister of the Environment is responsible for implementing this legislation. The Water Supply Act makes regional authorities and municipalities directly responsible for managing the surface water and groundwater resources. These authorities decide the priority of different water users and license the water users.

Water Management Is Decentralized

The planning of the extraction and distribution of drinking water is under the control of municipal authorities. Because extraction of water from underground or surface sources can have effects across municipal boundaries, regional water extraction plans are prepared by county authorities. The municipal authorities also have the general responsibility to protect the water sources from pollution. County authorities may specify protection zones around water extraction areas to prevent pollution. In the protection zones, the county authorities may issue orders governing permissible activities, including agricultural activities, to prevent the pollution of existing or future water supplies.

Water extraction permits for agricultural use are granted by municipal authorities for a maximum of 15 years for groundwater and 10 years for surface water. Water for irrigation is mostly from groundwater sources. Pumping permits specify how much water can be extracted per year. A permit from the municipal authorities is also required before liquids and materials that might pollute underground water can be buried in the soil, discharged, or stored on or in the ground.

Controls To Reduce Agriculture's Impact on Water Quality

In the mid-1980's, only about 2 percent of the groundwater supplies exceeded the maximum EU limit of 50 mg NO_3/liter. Now, however, the nitrate content in the groundwater is rising. In addition, many lakes and portions of the sea around Denmark have high enough concentrations of nitrogen and phosphorus to cause eutrophication problems. Much of this nitrate pollution is from agriculture due to inappropriate handling of manure in regions with high concentrations of livestock.

The principal legislation to protect water quality is the Danish Aquatic Environment Action Program of 1987. Its main objective is to reduce the leaching of nitrate by 50 percent by the year 2000. This reduction is to be achieved by eliminating runoff from storage of animal manure and silage, reducing nitrogen leaching from cultivated areas through better timing of fertilizer and manure applications, growing winter cover crops, and limiting the volatilization of ammonia from animal manure.

The country has made progress to implement its 1987 policy concerning livestock manure storage. In 1991, more than 80 percent of all operations with livestock met the law's manure storage standard. This level is 30 percent better than in 1987 when the policy was introduced. The Government has provided partial subsidies for investments in manure storage facilities.

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Authors: Jac C. Heckelman and Gary Vocke

Demographics

Population	5.2 million (1992)
Population growth rate	0.2% per year (1992)
Population density	122 per square km (1992)
Urban population	87% of total population (1990)
Urban growth rate	0.4% per year (1980-90)

Economics

Gross domestic product	$130,960 million (1990)
GDP growth rate	2.4% per year (1980-90)
GDP per capita	$25,678 (1990)

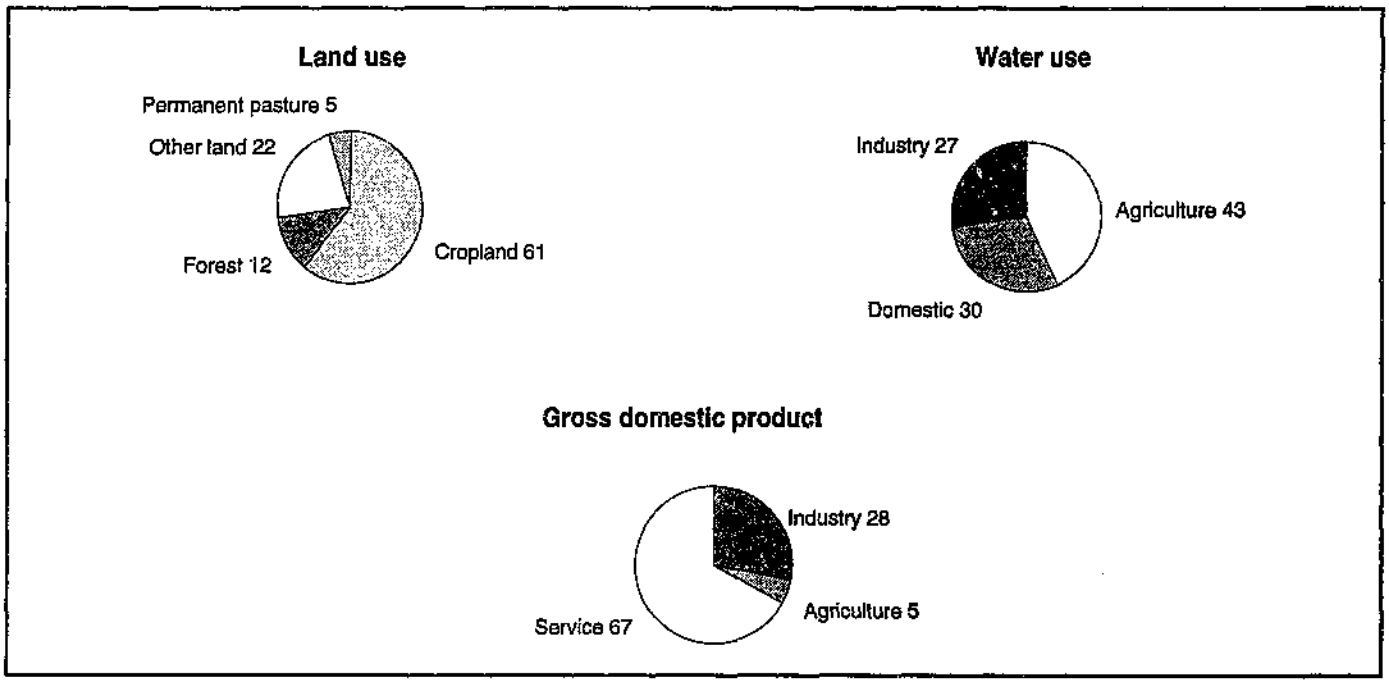
Environment

Land area	42,370 square km
Irrigated land	17% of cropland (1987-89)
Average fertilizer use	243 kg/ha cropland (1987-89)
Average pesticide use	7,729 metric tons active ingredient (1982-84)
Livestock contribution to methane	140,000 metric tons (1989)
Wet rice contribution to methane	NA
Greenhouse gas emissions	69 million tons CO_2 equivalent
Greenhouse gas emissions per capita	13.5 tons CO_2 equivalent
Land protected	9.8% of total land (1990)
Number of known threatened animal species	17 (1990)

Climate: temperate; humid and overcast; mild, windy winters and cool summers.

Environmental problems: air and water pollution; North Sea pollution; hazardous waste sites; pollution from animal manure.

NA = Not available/applicable.



Egypt

Egyptian water management is focused on the Nile River and the High Aswan Dam, which provides almost all of the country's water supply. The High Aswan Dam was constructed in 1968 to ensure the availability of water for both Egypt and Sudan. Construction of the High Aswan Dam significantly increased both the supply and reliability of water for irrigation, the principal use of water in Egypt. Virtually all cropland must be irrigated to be productive.

Government Water Management

The Ministry of Irrigation is responsible for the investigation, planning, construction, and maintenance and operation of all irrigation and drainage works in the country under the Water Law of 1953. Farmers are not required to pay the Ministry any water charges for operation and maintenance or any charges toward the capital cost of the waterworks infrastructure. Farmers are required only to maintain the last common canal of the system and their devices for lifting the irrigation water to their field. The power used to lift the water from the supply channel to the fields is subsidized.

The Government faces problems of significant salinization of irrigated areas. The cause of much of this salinization is that a drainage system was not constructed to prevent the water table from rising when the completion of the High Aswan Dam allowed perennial flood irrigation. A drainage network is now under development to stop the salinization process and to recover lost and damaged soils.

The Government provides incentives to encourage private capital to develop new irrigated lands. The incentives include low-interest loans with grace periods. However, water permits from the Government for newly developed land require the use of drip or sprinkler irrigation systems.

Pollution Law Not Enforced

The 1982 River Nile Control Law protecting the Nile River from pollution has not been enforced. The standards were considered too strict. Shortly after the law was enacted, the Government was forced to grant dispensations to polluters because it was not economically feasible for them to comply with the regulations.

International Agreements

About 85 percent of the Nile River water supply at Aswan comes from the Ethiopian Plateau. The White Nile flows from Lake Victoria in Kenya, Uganda, and Tanzania, providing the remainder of the total water supply at Aswan. Nearly half of the White Nile is lost through evapotranspiration in the swamps in south Sudan and on the Victorian Plateau.

Egypt and Sudan signed the Nile Water Agreement of 1959 concerning their use of the waters of the Nile River. In 1959, the two countries also established a permanent joint technical commission to formulate and implement cooperative projects. In 1964, the commission began to cooperate with the other countries along the Nile River. Now, eight of the nine countries sharing the Nile are full participants in the commission; Ethiopia is only an observer to the commission.

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Authors: Jac C. Heckelman and Gary Vocke

Demographics

Population	56.4 million (1992)
Population growth rate	2.3% per year (1992)
Population density	57 per square km (1992)
Urban population	47% of total population (1990)
Urban growth rate	3.1% per year (1980-90)

Economics

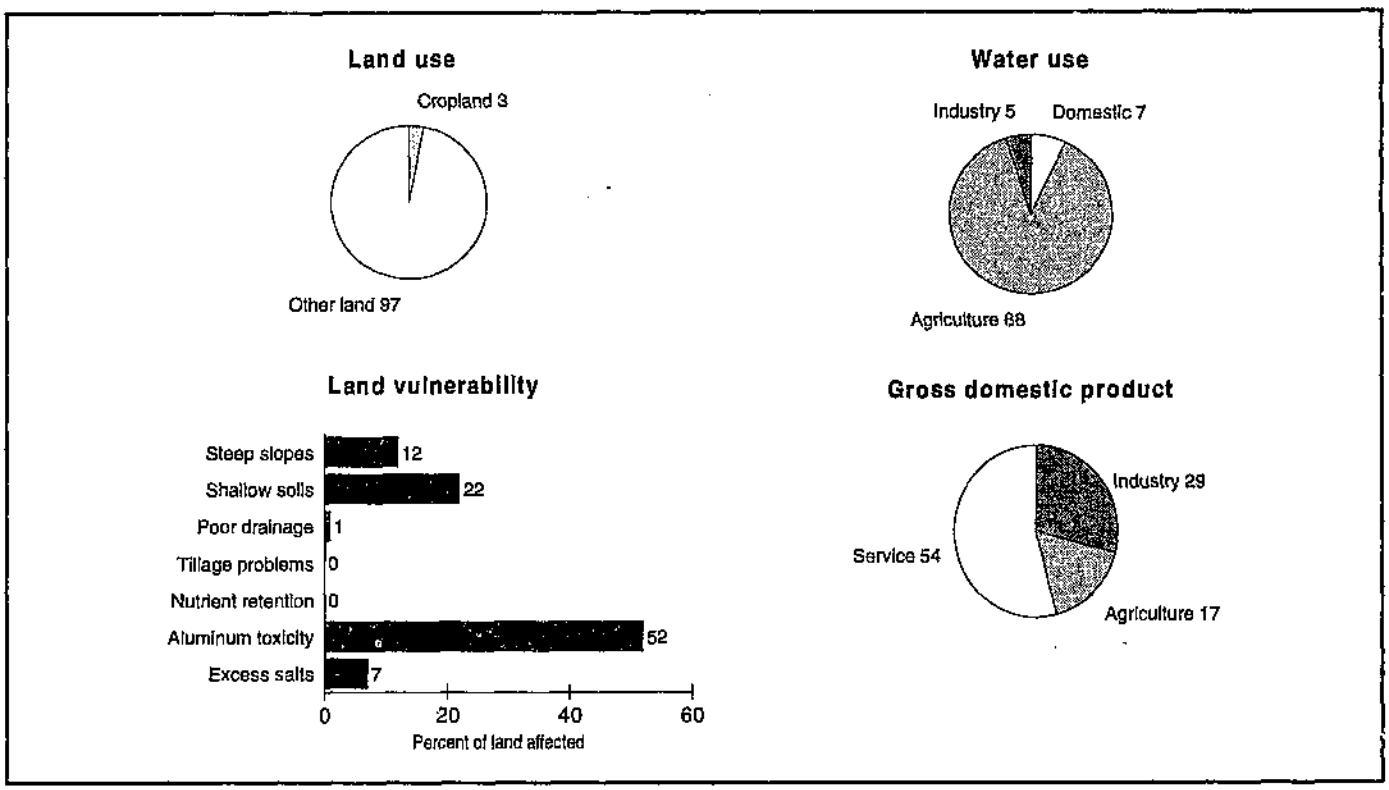
Gross domestic product	$33,210 million (1990)
GDP growth rate	5.0% per year (1980-90)
GDP per capita	$637 (1990)
Total external debt	126.5% of GNP (1990)

Environment

Land area	995,450 square km
Irrigated land	99% of cropland (1987-89)
Average fertilizer use	384 kg/ha cropland (1987-89)
Average pesticide use	19,567 metric tons active ingredient (1982-84)
Livestock contribution to methane	220,000 metric tons (1989)
Wet rice contribution to methane	260,000 metric tons (1989)
Greenhouse gas emissions	91 million tons CO_2 equivalent
Greenhouse gas emissions per capita	1.8 tons CO_2 equivalent
Land protected	0.7% of total land (1990)
Number of known threatened animal species	28 (1990)

Climate: desert; hot, dry summers with moderate winters.

Environmental problems: Nile is only perennial water source; increasing soil salinization below High Aswan Dam; hot, driving windstorm called khamsin occurs in spring; water pollution; desertification; oil pollution; soil damage and loss.



France

The Ministry of Environment is responsible for coordinating the other Ministries to manage the country's water resources. The Ministry of Agriculture, for example, has national management responsibility for irrigation and drainage. Local authorities, prefects of the departments, and six basin agencies are responsible for directly regulating and authorizing the use of water resources for water supplies and for disposal purposes.

Water Rights

The State has full property and usage rights to public surface waters. Public surface waters are defined as all navigable waters and all non-navigable water bodies supplying water to these navigable waters; waters required for public water supply; and water needed for agriculture and industry. Authorization from the prefect is required before water can be taken from public waters for agricultural and industrial use and a fee must be paid. This authorization can be modified or revoked at any time, without compensation, in the interest of public health or to reconcile the interests of current and future users. When extraction is discontinued, the local water authority must be informed.

This current definition of public water is the result of 1964 legislation. Prior to 1964, only navigable and floatable waters belonged to the public domain. This change from a physical use definition to a public interest criterion substantially increased public waters.

Water extracted from nonpublic surface water also needs prefect authorization. This authorization cannot be revoked without payment of compensation.

Rain water and spring water may be appropriated by private persons, but their property right is limited. If these waters meet the definition of public surface waters, the landowner may not impede their natural flow; nor may the landowner deprive any nearby community of the flow from these waters.

Groundwater cannot be claimed by any private individual. The right to extract groundwater is linked to the land. Landowners have property rights only to groundwater they have extracted. Thus, if a landowner's well dries up because of the activities of others, no compensation can be claimed. All withdrawals of groundwater for nondomestic purposes above a certain level must be reported to the water authorities.

Issuance, monitoring, and enforcement of waste discharge permits is the responsibility of the prefects. Authorization is required for any runoff, drainage, or discharge of used waters or materials into groundwater, surface water, or seawater that can alter the quality of these receiving waters. This authorization is not a right to pollute, nor does it reduce responsibility for any damage to fauna and the aquatic environment.

Water Resources Development and Management

All water resources in France are governed by its 1964 Water Law. Under this law, the country is divided into six large river basins. For each of these basins, there are two key institutions: the basin committee and the basin agency. The functions assigned to these institutions are water resources planning, administration of fees for water withdrawal and effluent disposal, and providing financial assistance to communities and industries to undertake water pollution control schemes. The basin institutions are given considerable independence from the National Government.

The basin committee is composed of equal numbers of representatives of water users, local governments, and the National Government. The committee decides upon the desired level of water quality. The committee then develops a 5-year plan of facilities to be constructed and other activities needed to achieve this quality level. Then, the level of subsidies or loans necessary to induce the water users to carry out these activities is determined and added to projected operating expenses of the agency. The committee tends to rely more on negotiation than on economic calculations in reaching agreement among its members about the level of subsidies or loans needed. Volumetric fees are then set to obtain this total from the water users for water extraction and for the disposal of wastes into water bodies.

These fees are collected by the basin agency and disbursed among the water users according to the 5-year plan. The basin agency is neither owner nor executor of the works that it promotes. Execution of the works is the responsibility of the municipalities, the department, or private sector companies.

Large water transfer projects that supply water to irrigators and nonagricultural users are developed and managed by semigovernmental corporations. The

stock of the corporation can be owned by various entities, but public bodies must always hold a majority interest. This mixed corporation permits local, private interests to buy stock so they can influence management of the project. However, because its financial resources include public funds, it is subject to governmental control. Because all necessary construction qualifies as public utility works, the corporation can acquire land through expropriation proceedings.

The corporation has to get a concession to extract water from the river basin authority and pay a fee to the authority for the water used. If the corporation's charges to its customers result in receipts exceeding expenses, the profit is given to the Government. The water charges for irrigation water from such a supplier can be subsidized when the Government decides that irrigation in that particular area should be promoted.

Environmental Controls on Agriculture

As production practices intensify, agriculture has become a major polluter of the country's water supplies. Rising nitrate levels have been linked to regional concentrations of intensive livestock production units. Generally, France's strategy for reducing nitrate pollution of groundwater is to appeal to farmers to voluntarily follow good agricultural practices, including maintaining vegetative cover, balancing nitrogen fertilizer applications with crop needs, and improving the management of fallow land over the winter.

Legislation allows the Government to directly control agriculture's potential to pollute water. The Water Act of 1976 provides for the regulation of specified activities to protect water quality. Under this Act, some agricultural activities, such as fertilizer stockpiles on farms, livestock farming, slaughterhouses, and grain silos, are subject to regulation. Under these provisions, livestock farms above a certain size are subject to strict regulations. To limit the possibility of pollution by livestock wastes, farm-level evaluations are made and action taken to manage excess manure.

The Code of Public Health provides authorities for the Government to designate protected areas surrounding sources of drinking water. In protected areas, activities including farming practices not covered by the "classified installations" legislation are regulated to ensure the safety of the water, especially concerning nitrates and pesticides. To protect water supplies from atrazine, the Ministry of Agriculture and the trade organizations jointly developed voluntary guidelines on the appropriate use of the herbicide.

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Authors: Jac C. Heckelman and Gary Vocke

Demographics

Population	57.3 million (1992)
Population growth rate	0.5% per year (1992)
Population density	105 per square km (1992)
Urban population	74% of total population (1990)
Urban growth rate	0.6% per year (1980-90)

Economics

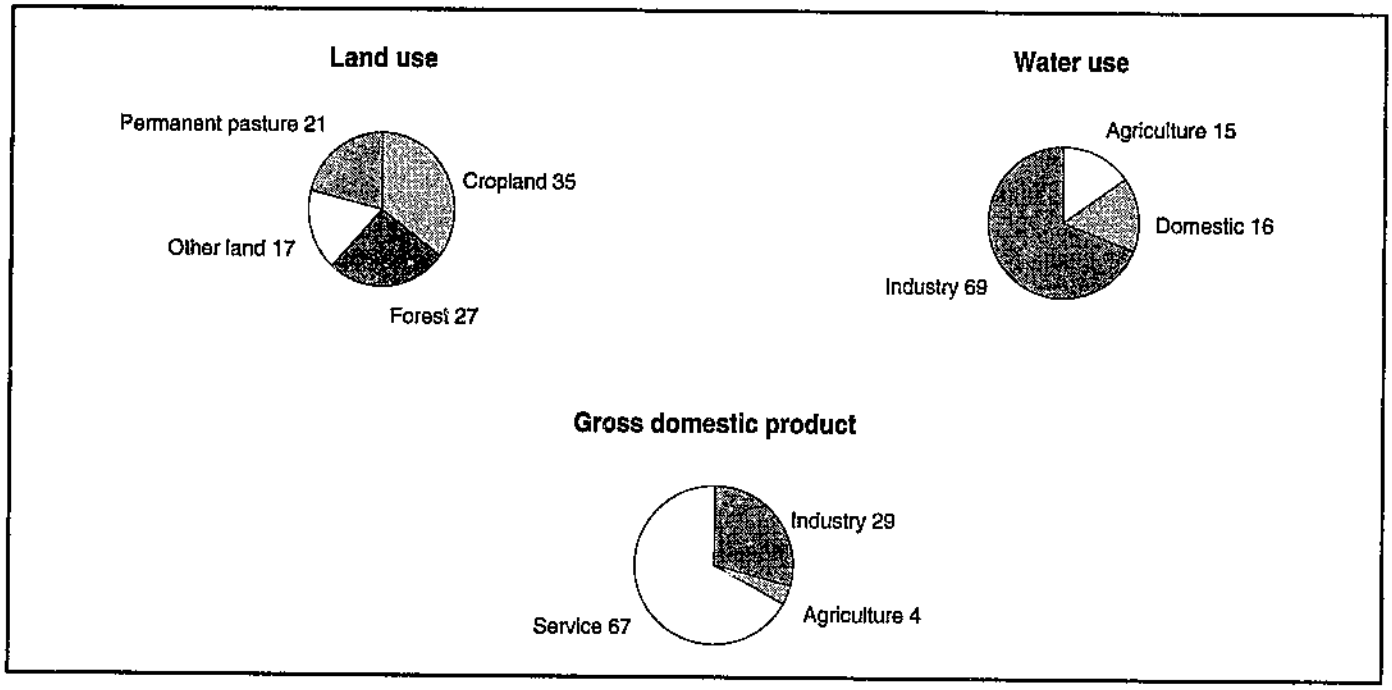
Gross domestic product	$1,190,780 million (1990)
GDP growth rate	2.2% per year (1980-90)
GDP per capita	$21,113 (1990)

Environment

Land area	545,630 square km
Irrigated land	6% of cropland (1987-89)
Average fertilizer use	312 kg/ha cropland (1987-89)
Average pesticide use	98,733 metric tons active ingredient (1982-84)
Livestock contribution to methane	1,300,000 metric tons (1989)
Wet rice contribution to methane	14,000 metric tons (1989)
Greenhouse gas emissions	515 million tons CO_2 equivalent
Greenhouse gas emissions per capita	9.2 tons CO_2 equivalent
Land protected	8.7% of total land (1990)
Number of known threatened animal species	33 (1990)

Climate: generally cool winters and mild summers, but mild winters and hot summers along the Mediterranean.

Environmental problems: most of the large urban areas and industrial centers are in Rhone, Garonne, Seine, or Loire River basins; occasional warm tropical wind known as mistral; air and water pollution; forest damage.



Germany

The German Constitution divides powers between the Federal Government and States. The Federal Government can only pass framework legislation regarding water. This framework legislation is then implemented by State legislation. The States are also responsible for enforcing their legislation. All surface waters and groundwater are under public management. The current framework legislation for water is the 1957 Federal Water Act. This legislation has been amended several times, especially to adjust for environmental needs.

States Are Responsible for Water Regulation

States have water and soil management associations that ensure rural water supply and regulate the draining and irrigating of agricultural areas. These associations are governed by representatives of the water users, selected by various methods.

With few exceptions, a permit or a license from the local water authorities is required before any water can be extracted or wastes discharged into water bodies. These consents give the user the right to use water for a specific purpose. A permit is issued after a public hearing, and cannot be revoked without paying compensation. A license can be issued without a hearing, but it can also be withdrawn without any compensation. Extraction of groundwater for farming purposes, except for irrigation, is allowed without a permit or license.

Development of irrigation is by individuals or associations. Associations are entitled to collect the necessary fees from the users to operate and maintain the waterworks. Use of water for irrigation can be by permit or license.

Controls on Agriculture To Protect Water Quality

The West German Drinking Water Ordinance was revised in 1986 to be consistent with the EU Drinking Water Directive of 1980 that limited contamination of drinking water to 50 mg nitrate/liter. Because water and public health authorities can regulate and control water distribution, but not agriculture, their activities have generally focused on corrective rather than preventive measures to ensure that the drinking water meets the EU standard.

The Ministry of Agriculture and Ministry of Environment are promoting the use of best management practices (BMP's) to reduce agriculture's impact on the environment. When this voluntary approach does not work, States can legislate a regulatory approach under the country's three major Federal laws regarding nitrate contamination of water: the Federal Water Act, the Waste Management Law, and the Fertilizer Law. These Federal laws allow States to establish BMP's for all farmers, and stringent limitations in designated water protection areas (WPA's) for drinking-water wellheads.

Each State may develop its own program for controlling farming practices in a WPA. These State programs vary as to the extent they use incentives and/or penalties to get farmers to change their practices. One State, for example, levies a water tax to generate revenue to compensate the farmers in the WPA's. In some States, the water companies purchase the land from the farmers in the wellhead area and then lease it back to the farmers under stipulations governing farming practices. If the water company and the farmer cannot reach agreement, the State has the legal power to force an agreement.

Some States have placed controls on livestock waste disposal based on the Federal Waste Management Law. Generally, animal wastes are excluded from the definition of wastes if "the usual degree of agricultural application is not exceeded." The definition of "usual degree" varies from State to State. Two States with considerable livestock production have restricted the application of liquid manure during the winter to not more than 240 kg nitrogen/hectare. Other legislation regulates facilities for storing manure to avoid water pollution.

The Plant Protection Act of 1986 and the Regulations on the Application of Pesticides are aimed at reducing the possibility that pesticides will pollute drinking water supplies. This legislation is consistent with the EU standards regarding pesticide contamination of drinking water.

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Authors: Jac C. Heckelman and Gary Vocke

Demographics

Population	80.4 million (1992)
Population growth rate	0.5% per year (1992)
Population density	230 per square km (1992)
Urban population	84% of total population (1990)
Urban growth rate	0.5% per year (1980-90)

Economics

Gross domestic product	$1,488,210 million (1990)
GDP growth rate	2.1% per year[1] (1980-90)
GDP per capita	$24,003[1] (1990)

Environment

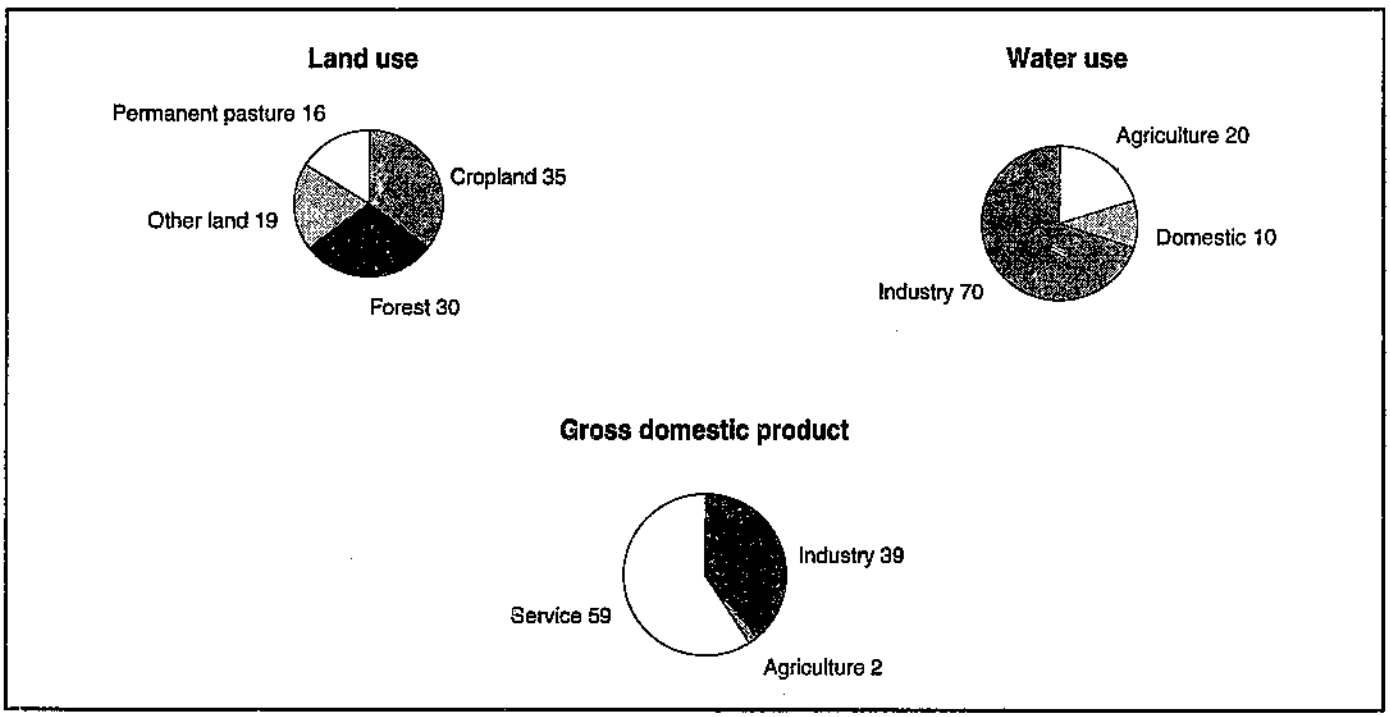
Land area	349,520 square km
Irrigated land	4% of cropland[1] (1987-89)
Average fertilizer use	405 kg/ha cropland[1] (1987-89)
Average pesticide use	14,133 metric tons active ingredient[1] (1982-84)
Livestock contribution to methane	1,250,000 metric tons (1989)
Wet rice contribution to methane	NA
Greenhouse gas emissions	1,140 million tons CO_2 equivalent
Greenhouse gas emissions per capita	14.7 tons CO_2 equivalent
Land protected	14.2% of total land (1990)
Number of known threatened animal species	22 (1990)

Climate: temperate and marine; cool, cloudy wet winters and summers; occasional warm, tropical foehn wind; high relative humidity.

Environmental problems: air and water pollution; groundwater, lakes and air quality in eastern Germany are especially bad; significant deforestation in the eastern mountains caused by air pollution and acid rain.

NA = Not available/applicable.

[1]Former West Germany only.



Hungary

Ninety percent of Hungary's water supply comes from sources outside the country, thus, water resources control and development projects have to be coordinated with other countries. Hungary has agreements on water management with its neighboring countries. The countries agree to refrain from any unilateral action that could adversely affect water interests in the neighboring country. In some agreements, provisions regulate the diversion of natural flows of the rivers.

Water Is Public Property

The Hungarian Constitution makes all water resources public property subject to state administration. The country's National Water Authority (NWA) is responsible for national, comprehensive water management under the supervision of the Council of Ministers. The NWA carries out its tasks through 12 district water authorities and local water management associations. Responsibilities of district water authorities are generally based on catchment areas. Districts sometimes own and operate waterworks. District authorities do not have representatives of users but supervise private sector activities through local water management associations set up by local councils.

The Water Act of 1964 provides the legal authority for the NWA to manage water quality. Each district water authority has a water pollution control unit. The Government relies primarily on effluent charges for controlling pollution. The charges are only a small part of the country's budget for waterworks.

Under the Water Bill, most waterworks construction and uses of surface and groundwater require government approval. Approval is not required for water for household use or for livestock. Nor is approval required for using water from wells with hand pumps on private property or for the use of precipitation falling on private property.

Approved construction and uses of water are filed in the Government's Water Record so that the quantity of unused water can be determined. During a severe drought, the Government will enforce water restrictions.

Controls on Use of Water for Irrigation

Within irrigation schemes, problems relating to water distribution are handled by irrigation boards composed of representatives of the farmers. If a farm is part of a publicly owned irrigation scheme, the farmer has to apply to the scheme's management for permission to withdraw water 1-3 days in advance of each irrigation. If a farm has an independent irrigation intake on a river, lake, reservoir, or well, there is no restriction to the time of withdrawal, but the capacity of the intake should not exceed the approved limit.

The Government restricts the use of water for irrigation if it has a high salt content. If the total salt content of water is less than 500 parts per million (ppm) and sodium percentage is below 30 percent, there are no restrictions. Up to 1,500 ppm, there are some restrictions on the use of water for irrigation. Water with a salt content over 1,500 ppm cannot be used for irrigation.

Financial Assistance for Irrigation

The Government provides loans of 20-30 years to cooperatives for constructing and equipping irrigation schemes. If the schemes are operated continuously and efficiently for 3 years after completion, a significant part of the loan is forgiven.

Water charges for farmers in an irrigation scheme are set by the Government. The charge has a fixed element based on the acreage to be irrigated and a variable element based on the quantity used. If the farmer gets the water under pressure from a pipeline, an additional charge covers the total cost of pressure maintenance. In addition, farmers who grow crops requiring less water are allowed preferential rates compared with those irrigating crops with higher water demand. There is no water charge for independent irrigation intakes.

Normally, water charges cover only 20-25 percent of the operational costs of the irrigation system. The difference is paid by the Government.

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Author: Gary Vocke

Demographics

Population	10.3 million (1992)
Population growth rate	-0.1% per year (1992)
Population density	112 per square km (1992)
Urban population	61% of total population (1990)
Urban growth rate	1.2% per year (1980-90)

Economics

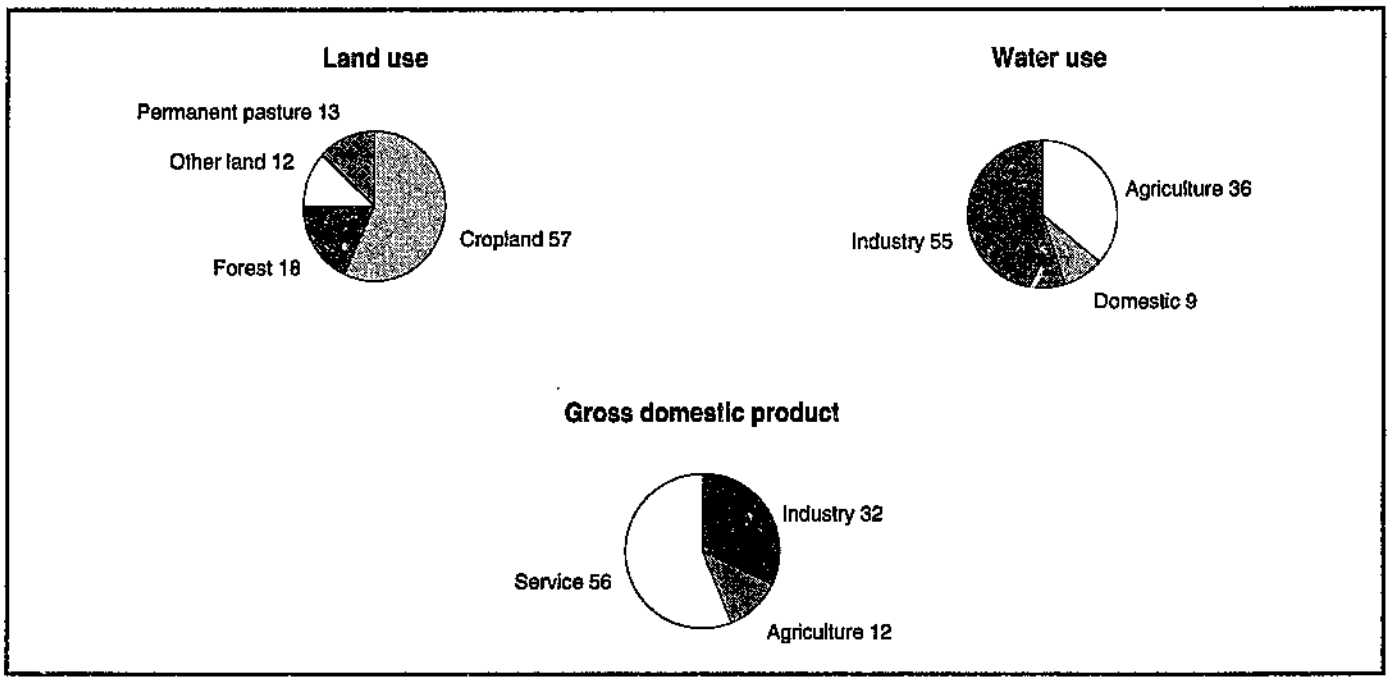
Gross domestic product	$32,920 million (1990)
GDP growth rate	1.3% per year (1980-90)
GDP per capita	$3,106 (1990)
Total external debt	67.8% of GNP (1990)

Environment

Land area	92,340 square km
Irrigated land	3% of cropland (1987-89)
Average fertilizer use	258 kg/ha cropland (1987-89)
Average pesticide use	27,595 metric tons active ingredient (1982-84)
Livestock contribution to methane	120,000 metric tons (1989)
Wet rice contribution to methane	9,000 metric tons (1989)
Greenhouse gas emissions	73 million tons CO_2 equivalent
Greenhouse gas emissions per capita	6.9 tons CO_2 equivalent
Land protected	5.5% of total land (1990)
Number of known threatened animal species	20 (1990)

Climate: temperate; cold, cloudy, humid winters; warm summers.

Environmental problems: levees are common along many streams, but flooding occurs almost every year; air pollution; water quality; lake pollution.



India

Under the Constitution, water matters are generally handled by the States. However, the Constitution authorizes Parliament to provide for adjudication of disputes on interstate rivers. Under this authorization, Parliament passed the Inter-State Water Disputes Act, which allows the Central Government to refer disputes to a Tribunal for final settlement. This procedure is important for resolving disputes about the sharing of river water among States along interstate rivers.

The National Water Policy of 1987 makes drinking water for people and livestock first priority over irrigation. Presently, near some large urban areas, agriculture is slowly yielding its water to urban uses. This reallocation is settled through political arbitration among interest groups, not through a market mechanism.

Surface Water Development for Irrigation

Almost half of the country's irrigated area receives water from sources directly under government control. These government-controlled supplies are mostly surface waters. Possibilities for run-of-river diversion schemes are now virtually exhausted, so dams will be required if irrigation by surface water is to be expanded. The rivers of the country carry most of their annual flow during the monsoon months of June-September. Thus, large storage reservoirs are required to capture a significant proportion of this runoff.

The Central Government reviews, approves, and helps to fund new projects. Since 1948, when the Government nationalized all irrigation projects greater than 100 hectares, the construction and operation of large irrigation projects has been the responsibility of State governments. State officials control these systems. Farmer organizations are rare.

Organizational arrangements differ from State to State. In most cases, the Government provides for the construction of the main dams, main and subsidiary canals, and all works up to the outlets. Generally, field channels and drains are to be constructed by the farmers. However, for selected projects, the Government has a program to construct field channels and drains, shape the land, and develop groundwater for conjunctive use. This program also arranges for supply of inputs and markets for crops. The objective of this program is to ensure a faster and better utilization of the irrigation potential provided by the main irrigation works already constructed by the Government.

The Government maintains the dams and canals and controls the release of irrigation water up to the last outlet. There is no nationwide procedure for allocating this water to farmers in public irrigation systems. Legislative regulations define how water shall be delivered to the irrigators in publicly managed irrigation schemes. In northern India, for example, farmers typically expect to receive canal water in proportion to land holdings. The water allocation is an asset of the land that they can use as they wish. In middle and southern India, irrigation water is rationed annually bythe government bureaucracy based on a cropping pattern also determined by the Government.

The water rates charged for crops irrigated from the public canals differ considerably among States, but are usually based on crop area. Neither the construction costs nor the full operation and maintenance cost are recovered from the farmers. The water charges that the farmers do pay go to the general budget, not to the irrigation schemes.

There is an older, tank-irrigation system that is still in use in the Deccan Plateau. The tanks provide surface irrigation water and also recharge wells in the command area. This type of irrigation system is not expanding. Instead, the area irrigated from publicly constructed reservoirs and privately developed groundwater sources has been expanding.

In recent years, the focus of irrigation planning has shifted from new construction toward making better use of existing facilities. Investments in drainage systems are needed because significant areas are affected by waterlogging and salinity because of poor irrigation water management.

Groundwater Development for Irrigation

Groundwater development has been made a priority. The surface water supplies from India's large rivers are mainly in the Ganges River Basin. These surface water resources are now almost fully developed; thus, irrigation development in this region will depend upon greater use of its abundant groundwater.

Although the Constitution enables States to control groundwater development, no States have legislation concerning groundwater development, which

contributes about 40 percent of all water used for irrigation. Privately owned wells are pumping 80 percent of the groundwater extracted for irrigation. Private well irrigation development has been promoted through investment credit incentives from the Government. The Government has also supported pumping by expanding its rural electrification program. In addition, farmers no longer have to pay for the electricity based on the amount used for pumping. Since 1982, the farmers pay a fixed rate per year based on the installed horsepower of the pump's motor. Pumping increased following this pricing change.

Heavy pumping of groundwater in some regions is lowering the water table. Excessive pumping along the coast has caused saltwater intrusion. There is no direct regulation of the quantity of groundwater that a farmer can extract. The government can, however, exercise control of groundwater pumping by limiting the financing for drilling new wells. In areas where there are already many wells, loans for new wells are available only after an assessment determines that another well will not have any adverse effects. This procedure does not prevent farmers from drilling wells with their own funds and using the water for irrigation.

In some areas, groundwater markets have developed with the private well owners selling water to their neighbors. The prices charged are several times greater than the rates for water from the public canals. The Government has developed public wells only where the farmers are too poor or their farms are too small or fragmented to justify a private well.

International Agreements

India and Pakistan are cosignatories to the Indus Basin Treaty of 1960. When the 1947 partition of British India gave to India the headwaters of the Indus river system and some of the major diversion structures that serve large irrigated areas in Pakistan, controversy arose regarding division of the waters between the two countries. The controversy led to armed conflict. The Indus Basin Treaty resolved the conflict by allocating the waters of the eastern rivers in the Indus Basin to India and the western rivers to Pakistan. The Treaty also included provisions to increase the supply of water in the Indus Basin.

The Indo-Bangladesh Joint Rivers Commission was established in 1972. The Commission formulates flood control works and is responsible for implementation of joint research projects on flood control problems. The Commission is also responsible for ensuring equitable mutual benefits from flood control and irrigation projects. In 1977, India and Bangladesh made an agreement defining how the Ganges water would be shared and guaranteed a minimum flow to Bangladesh. This agreement has now lapsed.

Agreements have been made with Nepal for the sharing of the waters of the Sarda River, the Gandak River, and the Kosi P ver. The Indo-Nepal Subcommission on Water Resources was organized in 1988 to promote cooperation in the multiple uses of water resources and in flood forecasting.

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Authors: Jac C. Heckelman and Gary Vocke

Demographics

Population	886.4 million(1992)
Population growth rate	1.9% per year (1992)
Population density	298 per square km (1992)
Urban population	27% of total population (1990)
Urban growth rate	3.7% per year (1980-90)

Economics

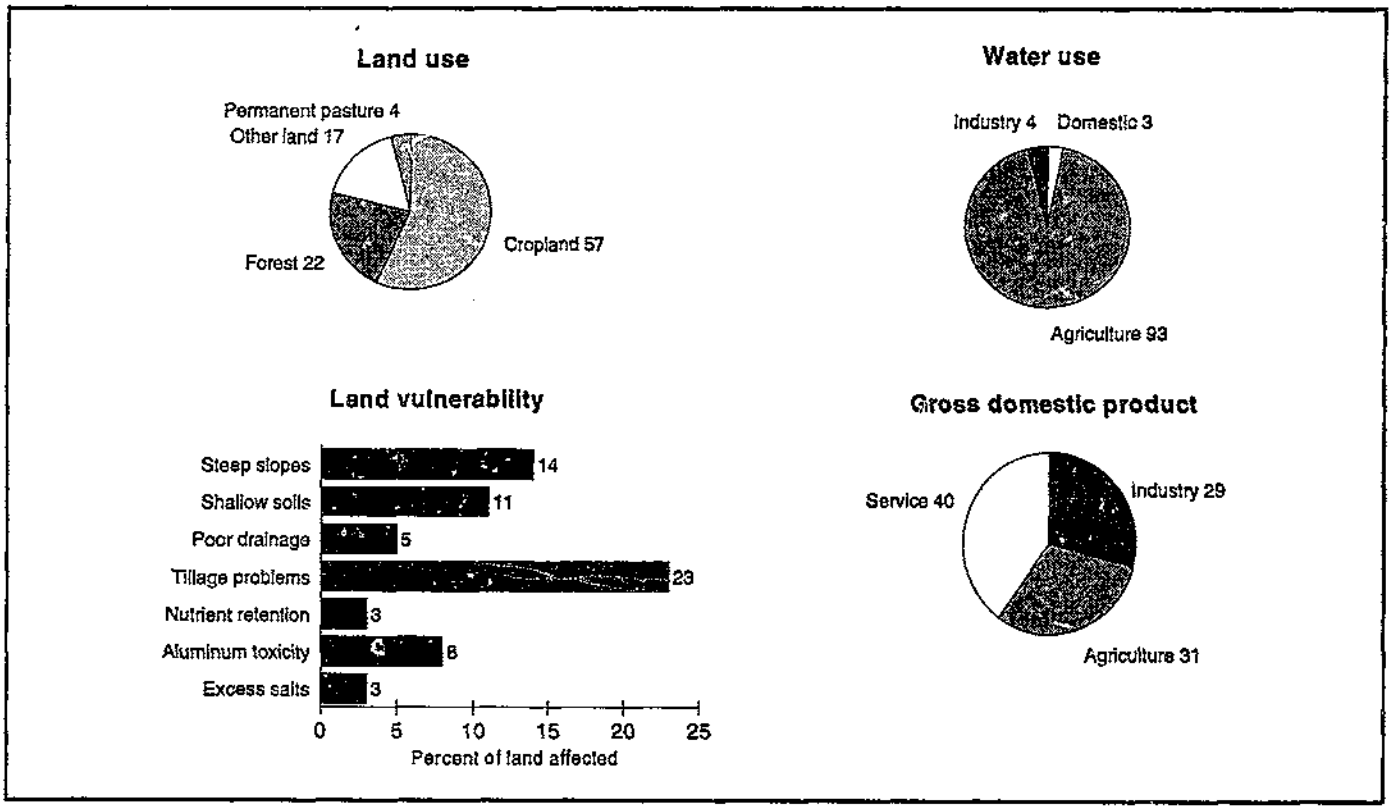
Gross domestic product	$254,540 million (1990)
GDP growth rate	5.3% per year (1980-90)
GDP per capita	$300 (1990)
Total external debt	25.0% of GNP (1990)

Environment

Land area	2,973,190 square km
Irrigated land	25% of cropland (1987-89)
Average fertilizer use	62 kg/ha cropland (1987-89)
Average pesticide use	53,087 metric tons active ingredient (1982-84)
Livestock contribution to methane	11,000,000 metric tons (1989)
Wet rice contribution to methane	19,000,000 metric tons (1989)
Greenhouse gas emissions	1,277 million tons CO_2 equivalent
Greenhouse gas emissions per capita	1.6 tons CO_2 equivalent
Land protected	4.1% of total land (1990)
Number of known threatened animal species	132 (1990)

Climate: varies from tropical monsoon in south to temperate in north.

Environmental problems: droughts, flash floods, severe thunderstorms common; deforestation; soil erosion; overgrazing; air and water pollution; desertification.



Indonesia

Under the 1945 Constitution, water is owned by the Nation's people and managed by the Government. No private ownership of water exists. The Water Resources Development Law of 1974 empowers the Government to develop and manage the country's water resources. The Ministry of Public Works has principal responsibility for managing the Nation's surface water resources. Responsibility for groundwater resources is with the Ministry of Mines and Energy. All people may use surface water without a permit for drinking, animal watering, washing, swimming, navigational and other nonconsumptive or limited consumptive purposes, provided such uses do not cause harm to the water resource. Wells less than 15 meters deep do not require a permit. A permit from the Ministry of Mines and Energy is required if the well is deeper.

The 1982 Government Regulation No. 22 on Water Management establishes that water management activities are to follow river basins. The legal and institutional structure for this water management responsibility was recently created with the establishment of 90 river basin units.

Development and Management of Irrigation

Historically, most of the water policy issues in Indonesia revolved around irrigated rice production and agricultural development. The importance of irrigation water for rice production is codified in the 1974 Water Resources Law. Rice fields have first priority to irrigation water, followed by other crops, including gardens and orchards. The expanded rice production that led to food self-sufficiency in the 1980's is directly linked to the Government's irrigation infrastructure investments. Most irrigation systems divert water directly from rivers, although some of the larger, more recently constructed systems rely on reservoir storage.

The construction of irrigation infrastructure is the responsibility of the Ministry of Public Works. When the construction is completed, the Central Government transfers the irrigation system to the Provincial government for operation and maintenance of the main system. Except for the island of Bali, the farmlevel responsibility for operation and maintenance is placed on the village chief, who appoints a village watermaster to take care of water distribution and mobilizes farmers for maintenance work. The arrangements on Bali are different because the irrigators are organized on the basis of common access to a water source. The boundary of the organization is independent of village administration.

Indonesia also has many communal irrigation systems where the Government is not directly involved. Communal irrigation systems are those owned, operated, and maintained by farmers and their local associations. These schemes account for a significant proportion of total irrigated areas in some parts of Indonesia.

Provincial Control of Irrigation

The water legislation related to irrigation basically codified the customary system of village water management. The Government is able to control irrigation water use when it formulates a cultivation plan for each irrigation system. This cultivation plan constitutes the legal basis of water-use rights within irrigation systems.

Before each rainy season, Irrigation Committees meet to decide the crop plan. The Irrigation Committees are made up of representatives from various government agencies. The process of planning annual cropping patterns and planting dates begins with the report about the expected cropping pattern at the village level. The Provincial Irrigation Service estimates the water available for irrigation, then develops a cropping plan of staggered planting dates for the farmers in a project. The objective is to optimize the use of water through control of the cropping pattern. Cultivation plans also specify periods in which villages are to provide labor for the maintenance of the irrigation system. The information is then sent to the village for the watermaster to implement.

During the irrigation season, the Provincial Irrigation Service makes an assessment of demand for irrigation water every 10-15 days. This determination is based on the area cropped and the type of crops. Allowing for conveyance losses, the demand is compared with supply to distribution decisions. With plentiful water, the system supplies water to irrigators with continuous flows. If the available supply drops below demand, the allocation to each tertiary block is reduced in proportion, and the farmers rotate water among themselves. As supplies decrease further, the Government begins to rotate supplies on a 7-10 day basis among villages. If the shortage becomes severe, rotation begins among secondary canals, and even between weirs along the waterway.

New Irrigation Policies

The collapse of the oil boom in the mid-1980's reduced revenues to the Government and prompted a program to transfer management of small-scale irrigation systems from the Provincial Irrigation Agencies to water users' associations. The users' associations will eventually be entirely responsible for the operation and maintenance expenses formerly provided by the Government. The Government, however, still retains public ownership of these systems.

Part of the operation and maintenance expenses of irrigation schemes have been covered by local land and property taxes. Financial transfers from the Central Government to the Provinces have been required to augment these local funds. However, the 1974 Water Resources Development Law provides that beneficiaries can be made to contribute to the operation and maintenance expenses of waterworks projects. A government policy statement anticipated that fees would become the predominant source of funding for operation and maintenance of public systems over a 15-year period. Recently, under this authority, some Provincial and local governments began collecting irrigation fees on a pilot basis.

Maintenance has not been sufficient to keep the irrigation systems in good operating condition. Thus, in many regions of the country, the emphasis is now switching from water development to infrastructure maintenance and improvement.

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Authors: Jac C. Heckelman and Gary Vocke

Demographics

Population	195.7 million (1992)
Population growth rate	1.6% per year (1992)
Population density	107 per square km (1992)
Urban population	31% of total population (1990)
Urban growth rate	5.1% per year (1980-90)

Economics

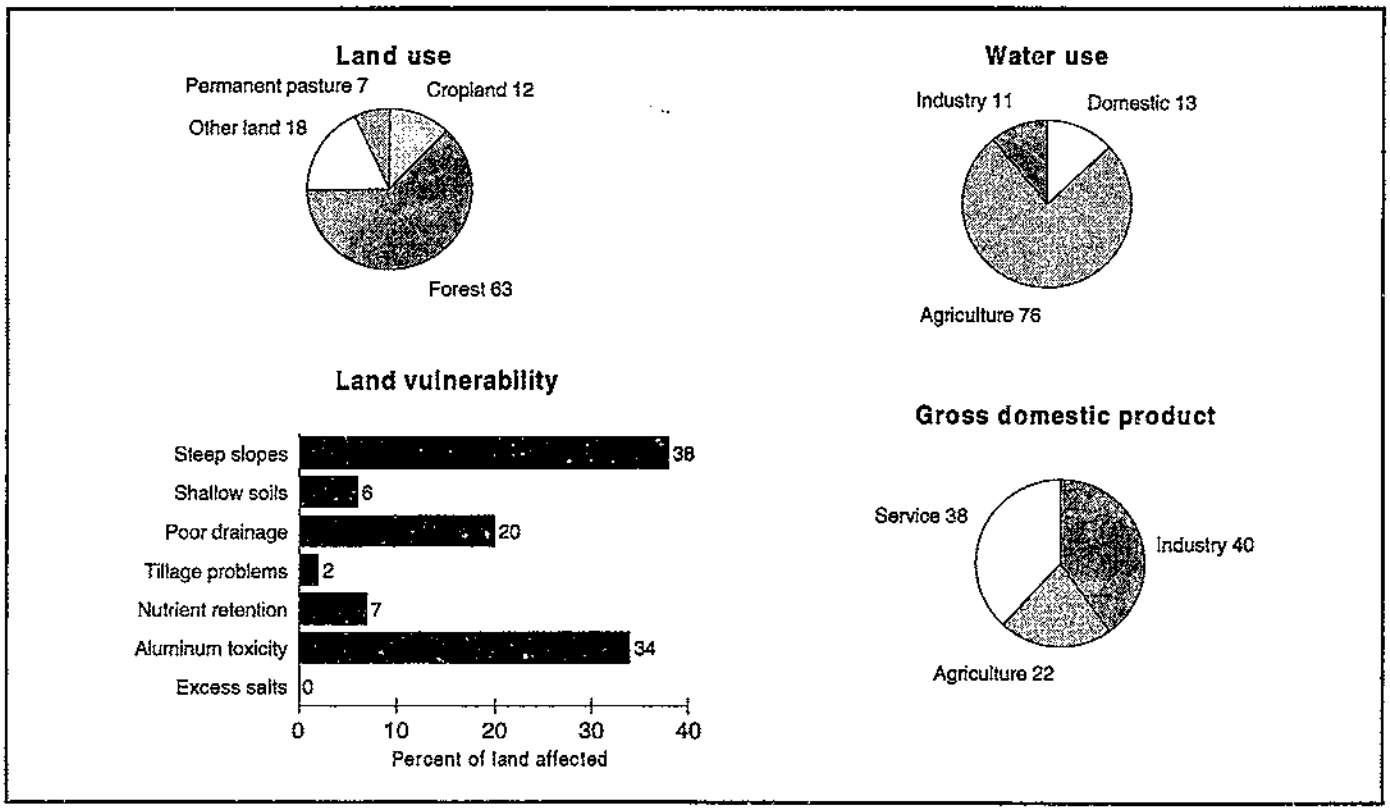
Gross domestic product	$107,290 million (1990)
GDP growth rate	5.5% per year (1980-90)
GDP per capita	$602 (1990)
Total external debt	66.4% of GNP (1990)

Environment

Land area	1,826,440 square km
Irrigated land	35% of cropland (1987-89)
Average fertilizer use	113 kg/ha cropland (1987-89)
Average pesticide use	16,344 metric tons active ingredient (1982-84)
Livestock contribution to methane	600,000 metric tons (1989)
Wet rice contribution to methane	5,100,000 metric tons (1989)
Greenhouse gas emissions	858 million tons CO_2 equivalent
Greenhouse gas emissions per capita	4.9 tons CO_2 equivalent
Land protected	9.3% of total land (1990)
Number of known threatened animal species	227 (1990)

Climate: tropical; hot, humid; more moderate in highlands.

Environmental problems: archipelago of 13,500 islands (6,000 inhabited); rainforest and watershed degradation; deforestation; occasional floods; severe droughts; tsunamis



Israel

Israel has almost fully developed its scarce water resources. Extraction is so great in some areas that the water resources are being depleted. In the country's two principal aquifers, excessive groundwater withdrawals have led to sea water and saline water intrusion. Having fully developed most of its water resources, the country is focusing on reusing domestic wastewater for irrigation and to recharge underground water supplies.

Israel's neighbors also have water shortages. Consequently, there have been disputes over those water resources that cross national boundaries. Many proposals and recommendations have been advanced concerning the use of regional water resources between Israel and its Arab neighbors, but no treaties have been enacted.

Government Responsibilities for Water Management

The Water Law passed in 1959 refuted existing private water rights to water sources that were based on previous Ottoman and British law. Water was made public property under the control of the Government. The Minister of Agriculture was given responsibility for water.

The Ministry of Agriculture allocates water to urban, industrial, and agricultural users through a licensing system. Licenses are valid for 1 year and state the quantities of water to be withdrawn and its use. The quantities and uses are listed on a water register and are transferable only with the permission of the Ministry.

The Water Law was amended in 1971 to improve control of water pollution. With this amendment, the Ministry can issue regulations controlling or prohibiting sources of pollution, the use of certain industrial and agricultural substances or processes, and the use of means of transport on or near water resources.

Other responsibilities of the Ministry include licensing aquifer recharge, control of new well drilling to avoid salinization or exhaustion of water resources, and the metering of all water supplied. The Law gives the Ministry authority to decree rationing zones and to define the priority of uses in times of water shortage. This authority includes water quotas for irrigation.

The public influences water policy through the Water Board, an advisory body to the Ministry. Representatives of the public make up two-thirds of the Board membership. The remainder of the members come from Government. The public also can go to the Tribunal for Water Affairs, a special court that takes appeals from the public against orders issued by the Ministry.

Irrigation Management

Irrigation in Israel developed in three phases. In the first phase, up to the mid-1960's, the main irrigation infrastructure was constructed and surface irrigation replaced sprinkler irrigation. Stage two brought increased use of micro-irrigation (drip and spray) and the development of sources of treated sewage effluent for irrigation. The Government used long-term loans and grants to encourage adoption of the new technology. By the 1980's, the incentive programs were stopped. The third phase has focused on cutbacks of water to agriculture and decentralizing the structure of the water administrative system.

Israel relies heavily on demand management. All water use is metered. Irrigation water is priced on a graduated schedule with respect to an allocation standard based on water use norms by crop and region. The lowest rate is charged for up to 70 percent of this allocation. From 70 percent to 100 percent, the rate is raised 67 percent. For 101 to 130 percent, the rate is 94 percent higher than the low rate. Any quantity of water above 130 percent of the allocation standard is charged at 220 percent extra. To encourage irrigators to use the latest technology, the Government is constantly reducing the level of the allocation standard as improved irrigation technology becomes available.

The rate for irrigation water is supposed to be based on the cost of supplying water to the user. However, delivery cost varies widely across the country because water supplies are concentrated in the north and must be transported to the arid south. About 80 percent of the country's water resources are located in the north. Because 65 percent of the arable land is in the south, large quantities of water are conveyed 200 km from the north to the south by a government entity, the National Water Carrier. To even out regional differences in delivery cost, the Water Law established a Water Charges Adjustment Fund. In those regions where water is relatively cheap, users pay not only delivery cost but also a surcharge, which

goes to the Fund. In the south where delivery cost is high, the Fund uses these surcharges to subsidize part of the expense of supplying water. The Government also contributes to this Fund. Capital and operational costs for water supplies to irrigators are only partly recovered by water charges.

Most irrigation water is supplied to settlements to manage. To decentralize the administration of water, regional associations of the settlements are being created to allow farmers a more active management role. In the water-abundant northeastern part of the country, these regional organizations operate their own waterworks.

Fresh Water To Be Reallocated

The nation plans to reallocate part of agriculture's fresh water to municipal uses. A lesser quantity of reclaimed waste water will substitute for this fresh water. Although agriculture's total water allocation will be reduced, agricultural output is expected to continue expanding by the use of additional water-efficient greenhouses and more water-saving drip and underground irrigation.

Israel now reuses 35 percent of its municipal wastewater, mostly for irrigation. The Government plans to raise the level of wastewater reclaimed for irrigation to 80 percent. Municipal authorities may sell this wastewater for agricultural or industrial use. A permit system by the health authorities is used to ensure that only highly treated waste water can be used to irrigate crops grown for direct human consumption.

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Demographics

Population	4.5 million (1992)
Population growth rate	4.0% per year (1992)
Population density	221 per square km (1992)
Urban population	92% of total population (1990)
Urban growth rate	2.1% per year (1980-90)

Economics

Gross domestic product	$53,200 million (1990)
GDP growth rate	3.2% per year (1980-90)
GDP per capita	$11,319 (1990)

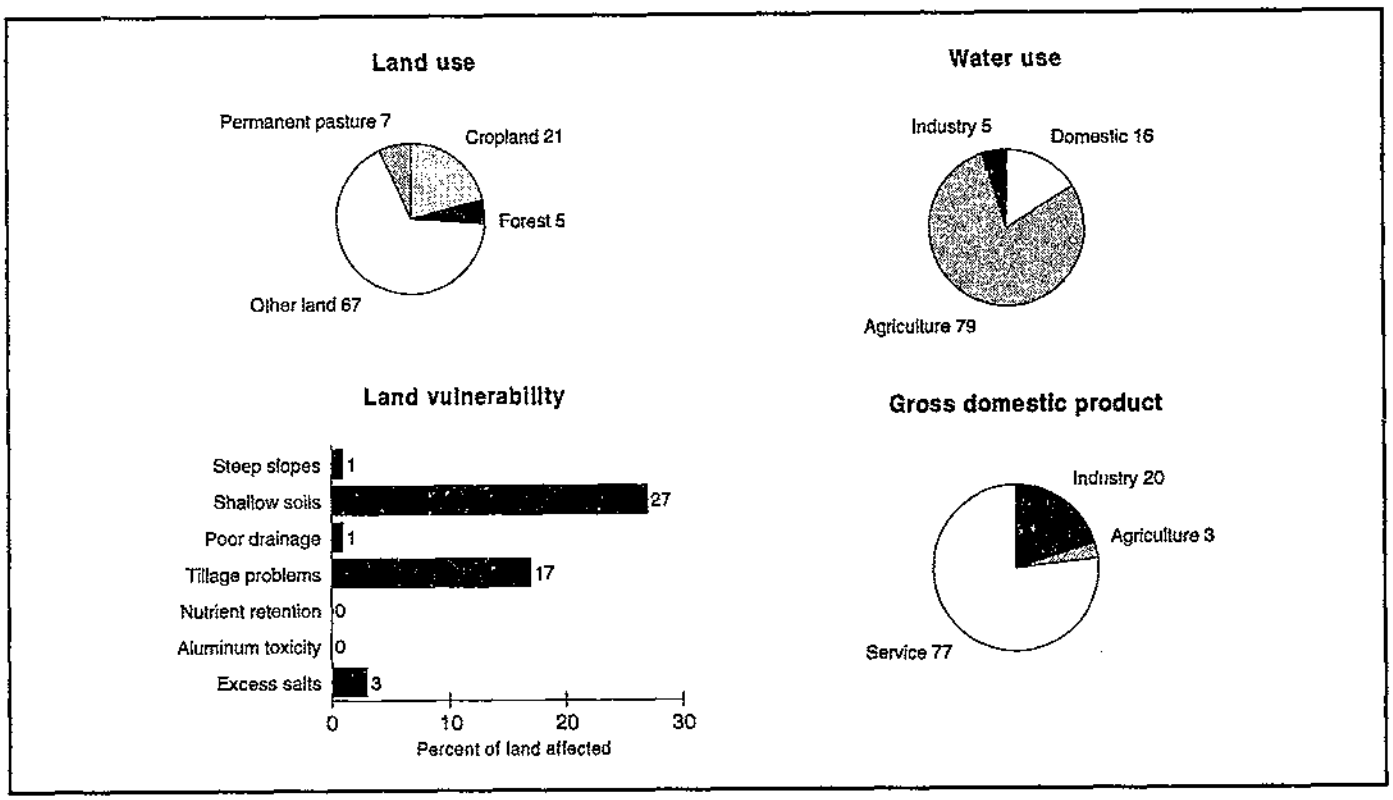
Environment

Land area	20,330 square km
Irrigated land	49% of cropland (1987-89)
Average fertilizer use	234 kg/ha cropland (1987-89)
Average pesticide use	847 metric tons active ingredient (1982-84)
Livestock contribution to methane	15,000 metric tons (1989)
Wet rice contribution to methane	NA
Greenhouse gas emissions	41 million tons CO_2 equivalent
Greenhouse gas emissions per capita	9.2 tons CO_2 equivalent
Land protected	10.9% of total land (1990)
Number of known threatened animal species	25 (1990)

Climate: temperate; hot and dry in desert areas.

Environmental problems: sandstorms may occur during spring and summer; limited arable land and natural water resources pose serious constraints; deforestation; water scarcity and pollution; stress on coastal resources.

NA = Not available/applicable.



Italy

Under the 1947 Constitution, the central and the local governments share responsibility for the management of water resources. At the national level, most aspects of surface and groundwater administration are with the Ministry of Public Works. Ministry responsibilities include registering of public water resources, allocating public waters, policing of surface water and groundwater, and establishing water use priorities. Relatively autonomous regional and inter-regional agencies under the Ministry are directly responsible for carrying out these functions.

Originally, the administrative boundaries of these autonomous agencies did not coincide with those of the drainage basins because they were political entities. This decentralized framework led to conflicts over scarce water resources crossing political boundaries. To help reduce some of these conflicts, legislation was passed in 1989 to superimpose the river basin as a new government unit. The River Basin Authorities are restricted to planning alone.

There are also public water-user associations for local water management. These associations are subject to varying degrees of control by the regional and inter-regional administrative authorities. The control ranges from registering the association statutes with the authorities to direct participation by the administrative authorities in the management of the association.

Administrative Allocation of Water Resources

Underground water supplies throughout most of the country are typically used for drinking water. Surface waters are generally used for irrigation and industry. These surface and underground water resources are classified as either public or private waters. Public surface waters are springs, watercourses, and lakes that have a public use. Administrative authorities decide in a public hearing whether or not a surface water is public water. These public waters are listed in Provincial registers and the lists can be modified by the administrative authority at any time.

The legal regime of groundwater resources is identical to that of surface water; groundwater may be declared public by administrative authorities. Generally, water remains private when it springs from, flows on, or lies below lands under private ownership. The landowner has the right to use this private water for domestic, agricultural, or industrial uses. Administrative authorities may specify districts in which groundwater extraction is controlled to protect the water balance. Outside of these protected districts, except for minimum distances between wells, groundwater extraction is free of administrative interference. The transfer of private groundwater (and private surface water) to others is allowed.

Public waters are allocated only by the administrative granting of a water-use right that specifies the amount of water to be used, its purpose, and the duration. Perpetual water-use rights are no longer issued. Exceptions to this granting requirement include small, customary water intakes for household consumption and landowner use of public groundwater for domestic needs.

Generally, water-use rights granted by administrative authority are subject to water charges. These charges vary according to the purpose and the amount of water used. Certain usages can be exempted from a water charge.

Administrative and judicial authorities may modify the existing water rights for the use of any public or private water at any time and to a considerable extent. Administrative authorities are required to give preference to municipal and domestic uses. Judicial allocation of private water resources between neighbors may take place whenever water is needed for domestic and/or irrigation purposes and the parties concerned are unable to reach an agreement.

Irrigation water, whether withdrawn from underground or diverted from surface waters, requires a state concession and payment of a fee to the state. Irrigation schemes diverting surface waters are usually established and managed by user associations. Irrigators pay fees to the user associations to cover expenses for building, maintaining, and operating the scheme.

Water Quality Protection

Issues concerning agriculture and water quality are focused on the intensive agriculture of the Po Valley, where half of the country's crops are produced on less than a quarter of its agricultural land. The country's pesticide and fertilizer use is concentrated in this area, and water supplies have been degraded by excessive use of these inputs.

Administrative authorities have the power to enforce drinking-water standards through regulation or

prohibition of polluting activities. In designated water protection areas, agricultural activities concerning use of pesticides, fertilizers, and manure can be regulated and even prohibited. The Government can also control input use. For example, when the concentration of herbicides in water supplies exceeded the limit in the Po Valley, the use of certain herbicides, including atrazine, was prohibited.

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Authors: Jac C. Heckelman and Gary Vocke

Demographics

Population	57.9 million (1992)
Population growth rate	0.2% per year (1992)
Population density	197 per square km (1992)
Urban population	69% of total population (1990)
Urban growth rate	0.6% per year (1980-90)

Economics

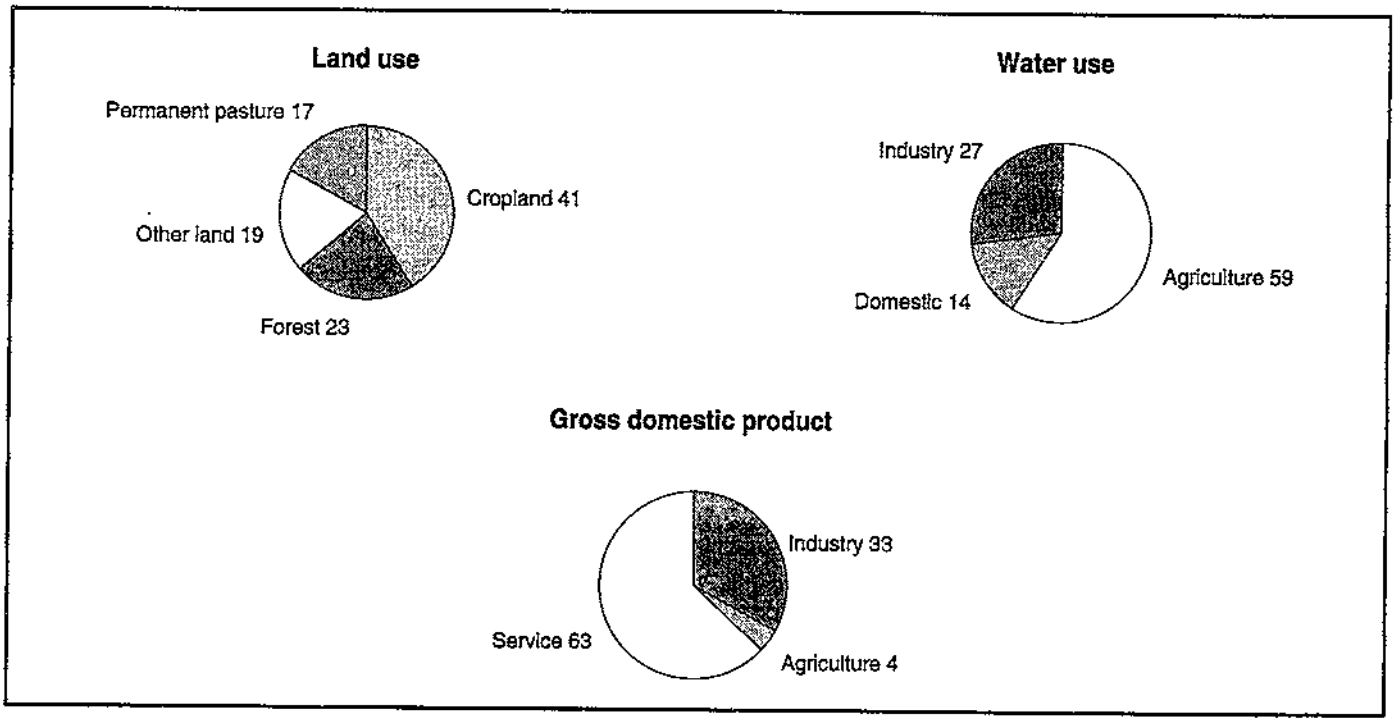
Gross domestic product	$1,090,750 million (1990)
GDP growth rate	2.4% per year (1980-90)
GDP per capita	$18,904 (1990)

Environment

Land area	294,020 square km
Irrigated land	26% of cropland (1987-89)
Average fertilizer use	172 kg/ha cropland (1987-89)
Average pesticide use	98,496 metric tons active ingredient (1982-84)
Livestock contribution to methane	600,000 metric tons (1989)
Wet rice contribution to methane	110,000 metric tons (1989)
Greenhouse gas emissions	547 million tons CO_2 equivalent
Greenhouse gas emissions per capita	9.5 tons CO_2 equivalent
Land protected	4.3% of total land (1990)
Number of known threatened animal species	34 (1990)

Climate: predominantly Mediterranean; Alpine in far north; hot, dry in south.

Environmental problems: regional risks include landslides, mudflows, snowslides, earthquakes, volcanic eruptions, and flooding; land sinkage in Venice; air and water pollution.



Japan

Japanese agriculture is a major user of the country's water supplies. Japan has well-developed and managed irrigation systems for rice production, supplied mostly from rivers. However, rising nonagricultural demands are leading to societal pressures to switch some of the water used for irrigation to supply expanding nonagricultural needs.

Water Rights

The country's River Law defines river water as public property and designates river administrators who are responsible for water rights. New water rights are granted only when there is enough unallocated water so that there should not be a water shortage more than once in a 10-year period.

When an applicant files for a water right, the river administrator then informs existing water users of the application. These users can submit claims against the water right application if they would be harmed. Typically, the river administrator will not grant a new water right if there are any claims. However, if the river administrator decides that the requested use of water is more beneficial to the public than prior rights, the administrator can grant the new water right. The applicant must then compensate the prior water-right holders for any loss incurred.

A water-right permit will specify the use of the water, how much can be taken, the method of taking the water, and period of the year that the water can be taken. The holder of a water right must follow these conditions. While the permit itself is only valid for a limited number of years, renewal of the water right is guaranteed as long as water use continues. Although a water right is property, it cannot be sold. The water right can, however, be transferred if the river administrator agrees to the transfer.

When there is a water shortage due to drought, the earliest water-right holders have priority, but should coordinate with other users. If the water users themselves cannot reach agreement on how to share the reduced supplies, the river administrator may intervene.

Groundwater is handled differently than river water. The ownership of groundwater under private land belongs to the landowner. A water right is not required for the landowner to use the groundwater.

Management of Irrigation

Irrigation is managed through Land Improvement Districts (LID's) organized according to the 1949 Land Improvement Act. Every LID holds its own water rights. The LID's are designed to deliver the right quantity of water to every plot at the right time and with drainage so that every plot can be drained independently of adjoining plots. The LID's primary and secondary canals and associated facilities are under the LID central management, while the tertiary irrigation facilities are managed by water user groups within the LID.

To create an LID, a farmer-originated petition must be first approved by the Prefecture governor. Then, two-thirds of all farmers in the area must vote for creating the LID. Each farm household is entitled to equal voting membership in the LID, regardless of the size of the farm. To cover its expenses, the LID can require its members to pay fees or perform labor.

Almost all irrigation facilities (reservoirs, barrages, pumps, main and lateral canals, farm ditches) have been and are constructed and rehabilitated at a high rate of subsidy by central and local governments. Financing varies with the size of the project. Much of the financing for construction of large projects is from the State and Prefecture governments. As project size decreases, the State and Prefecture share of the financing declines and the share borne by the irrigators, through low-interest loans to the LID, increases.

In principle, LID operation and maintenance expenditures are to be covered by fees collected from the farmers. In most cases, these fees are determined as a proportion to each farm's share of the total agricultural land area of the LID. Only a few districts base their fees on the quantity of water used. Even though municipal governments are not required to provide subsidies to the LID's, almost a quarter of the LID's receive municipal subsidies for operation and maintenance expenses.

Reallocation of Irrigation Water

Nonagricultural water use is increasing at a time when most water resources in natural streams are already taken. Thus, reservoir storage must be constructed to increase the flow. However, there are few remaining sites for reservoirs. To supply rising urban needs, irrigation water has been targeted for reallocation.

Because the River Law does not allow water rights to be sold, farmers have little incentive to give up their water rights. However, some irrigation water is being transferred. Under the River Law, the river administrator can reduce the quantity stated in water-right permit if the purpose for which the water is to be used has been discontinued entirely or partly.

Another way to increase urban water supplies is for municipalities to provide funds to LID's for waterworks construction to improve the efficiency of their irrigation facilities. Any savings of irrigation water that result from the improvements can be transferred to the municipality.

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Authors: Jac C. Heckelman and Gary Vocke

Demographics

Population	124.5 million (1992)
Population growth rate	0.4% per year (1992)
Population density	332 per square km (1992)
Urban population	77% of total population (1990)
Urban growth rate	0.7% per year (1980-90)

Economics

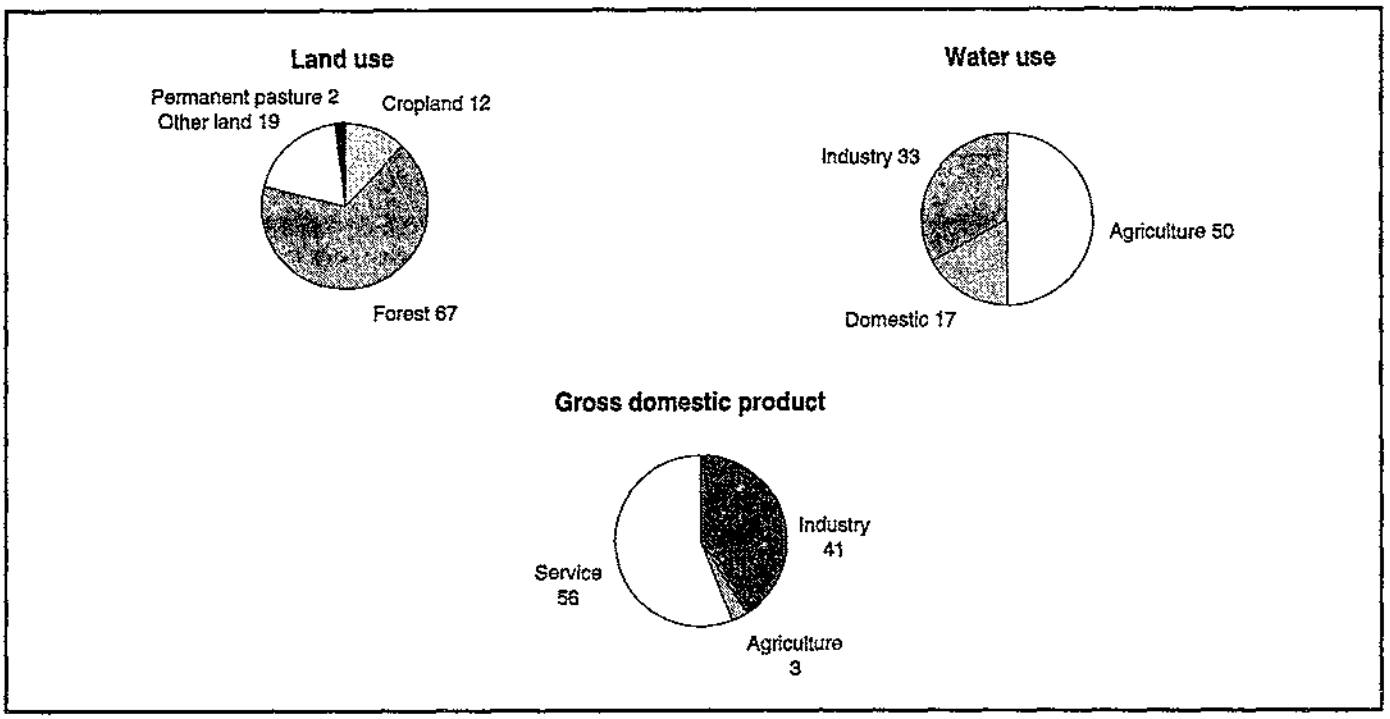
Gross domestic product	$2,942,890 million (1990)
GDP growth rate	4.1% per year (1980-90)
GDP per capita	$23,829 (1990)

Environment

Land area	374,744 square km
Irrigated land	62% of cropland (1987-89)
Average fertilizer use	425 kg/ha cropland (1987-89)
Average pesticide use	32,000 metric tons active ingredient (1982-84)
Livestock contribution to methane	280,000 metric tons (1989)
Wet rice contribution to methane	1,400,000 metric tons (1989)
Greenhouse gas emissions	1,113 million tons CO_2 equivalent
Greenhouse gas emissions per capita	9.1 tons CO_2 equivalent
Land protected	6.4% of total land (1990)
Number of known threatened animal species	40 (1990)

Climate: varies from tropical in south to cool temperate in north.

Environmental problems: many dormant and some active volcanoes; about 1,500 seismic occurrences (mostly tremors) every year; subject to tsunamis; air pollution; marine degradation.



Jordan

Jordan is an arid country with a shortage of water resources. Its water resources are a public good that is allocated by the Government under the Ministry of Water and Irrigation. The Government's allocation strategy for groundwater resources has been to develop them for both agricultural and nonagricultural uses. Surface water resources, in contrast, have principally been developed for irrigation.

Jordan Valley Development

Until the 1960's, limited use was made of surface waters in the Jordan Valley. Development of the Valley began with the enactment of a law allowing the expropriation of land and water rights within irrigation project areas for redistribution in accordance with an efficient irrigation system layout. The irrigation infrastructure is then developed and operated by the Government.

There are specific provisions in the 1952 Law of the Settlement of Land and Water Rights that protect existing water rights in the area in which the Government develops an irrigation project. The Government guarantees those water rights already on the Register of Rights in accordance with the 1952 Law. When the project is completed, any water supplies developed by such projects that exceed the amount of water registered in the Register of Rights become government property.

With the exception of those farmers who already had registered water rights, a permit from the Government is required before water is supplied to a farmer. The permit specifies the amount of water that may be used and the purpose of its use. The farmers who had registered water rights are able to use water up to the limit of their right without a permit. Use of any water above the level of their registered right is by permit only.

The price charged to the irrigators for this irrigation water is set by the Government, and presently is less than the cost to the Government to develop and maintain the schemes. The fee charged to the irrigator is at the same rate per unit of water regardless of the quantity used. In contrast, to encourage municipal conservation, publicly supplied water is priced at a progressive rate per unit as the volume used rises.

Delivery of irrigation water from canals is controlled by the Government. For example, a semi-demand system is used in the East Ghor Canal Project, which supplies 80 percent of the Jordan Valley irrigation water. A farmer is allowed to receive water once a week. Depending upon the quantity of water needed, the farmer will choose one of four delivery durations: 6, 12, 18, or 24 hours. The water will be delivered to the farmer within 24 hours of the request. Farmers can skip their weekly turns without jeopardizing their right to water.

Well Irrigation Development

In contrast to the government-subsidized development of the Jordan Valley, well irrigation in the highlands is developed privately. The highland farmers bear the entire cost of developing and maintaining their small-scale well irrigation. A permit from the Government is required before a well can be drilled.

If more than 5 cubic meters of water is to be pumped from the well per day, then an abstraction permit specifying the quantity that can be pumped is required. This water right is registered in the Register of Rights. If the water is to be used for irrigation, the water right is attached to a specified plot of land. The right cannot be transferred separately from the land. In contrast, if the water is to be used for something other than irrigation, the water right under the government permit is a personal right and may be transferred separately from the land on which the water occurs. When the water right is transferred separately from the land, the new holder of the water right has a legal right of way to the land where the water occurs, but must compensate the landowner if any damage ensues in obtaining the water.

In some locations, pumping is excessive and is depleting the groundwater supply. To protect groundwater supplies, the Government may refuse the granting of new permits, and may modify the conditions set down in existing permits. In some areas, there is now a ban on new wells.

Changes To Make More Efficient Use of Irrigation Water

More than half of the farmland is now under drip irrigation, making very efficient use of the water. Development of drip irrigation began in the mid-1970's in plastic greenhouses for growing high-value fruits and vegetables. Development of drip irrigation has been financed privately.

The Government is switching its Jordan Valley, open-canal networks to pipe networks to reduce water losses. The pipe networks are designed to operate on demand and have meters installed at the farm turnout. The Government still retains the authority to set the upper limit on the amount of water that can be delivered to an irrigator. The setting of this limit is made in accordance with availability of water and the crops grown.

Presently, urban wastewater accounts for only a small part of the country's irrigation water. The Government plans to expand the use of treated wastewater for irrigation.

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Authors: Julie Hopenfeld and Gary Vocke

Demographics

Population	3.6 million (1992)
Population growth rate	4.1% per year (1992)
Population density	39 per square km (1992)
Urban population	61% of total population (1990)
Urban growth rate	4.1% per year (1980-90)

Economics

Gross domestic product	$3,330 million (1990)
GDP growth rate	3% per year (1991)
GDP per capita	$1,041 (1990)
Total external debt	221.1% of GNP (1990)

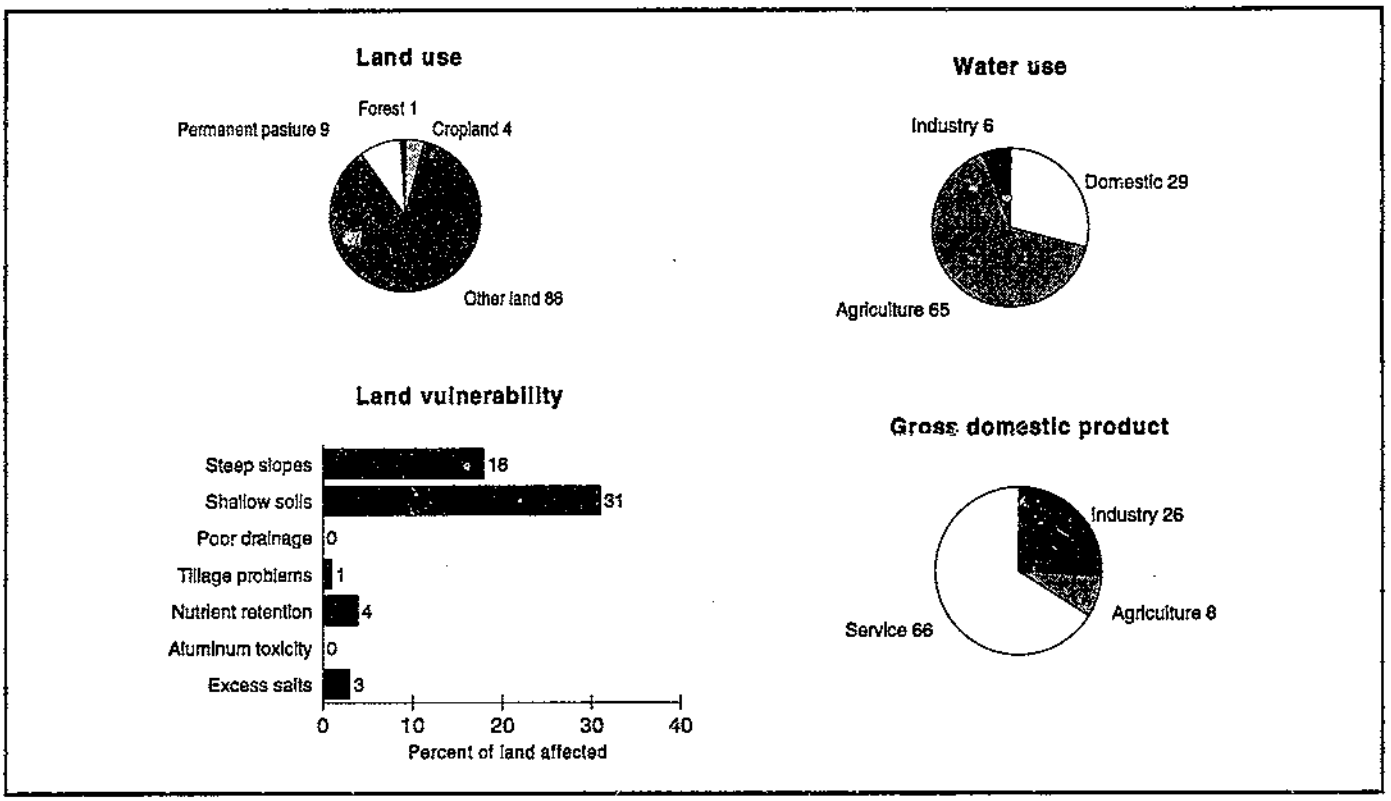
Environment

Land area	91,540 square km
Irrigated land	15% of cropland 1987-89)
Average fertilizer use	63 kg/ha cropland (1987-89)
Average pesticide use	NA
Livestock contribution to methane	10,000 metric tons (1989)
Wet rice contribution to methane	NA
Greenhouse gas emissions	7 million tons CO_2 equivalent
Greenhouse gas emissions per capita	1.9 tons CO_2 equivalent
Land protected	1.0% of total land (1990)
Number of known threatened animal species	16 (1990)

Climate: mostly arid desert; rainy season in west (November - April).

Environmental problems: lack of natural water resources; deforestation; overgrazing; soil erosion; desertification; water scarcity; access to clean water; overpopulation.

NA = Not available/applicable.



Kenya

The Water Resources Act vests the country's water resources in the Central Government. The Ministry of Water Development is responsible for the development, conservation, and utilization of water resources. Under the Water Resources Act, nobody can divert, extract, obstruct, or use water without a permit from the Ministry of Water Development. Approval is also required before discharging domestic, industrial, or agricultural wastes into any water body.

Water Resource Development

The Water Resources Act allows parastatals, individual departments, private companies, and individuals to develop water resources for beneficial uses provided that a permit is first obtained from the Ministry of Water Development. For multipurpose water development, coordination will be by an interministerial committee of the water and land agencies set up by the River Basin Authority responsible for that basin.

Irrigation Infrastructure

Water use by agriculture is limited in Kenya. Only about 2 percent of the country's cropland is irrigated, ranging from large-scale, government-owned schemes involving thousands of acres on which farmers work for wages to small, individually owned and irrigated plots of 3-4 acres.

The National Irrigation Board (NIB) was established by the 1966 Irrigation Act to initiate and operate large-scale irrigation projects; formulate and execute national irrigation policies; raise funds for developing large-scale irrigation schemes; coordinate settlement in these schemes, organize market outlets for the produce from the irrigation schemes; and ensure manpower development for irrigation. Only operation and maintenance costs of irrigation schemes are charged to farmers.

A separate organization, the Irrigation and Drainage Branch (IDB), within the Ministry of Agriculture is responsible for promoting smallholder irrigation in the country. The IDB has Provincial Irrigation Units (PIU's) to decentralize its activities. Through these offices, the Ministry of Agriculture is responsible for helping develop small irrigation schemes for crop production (and the water supplies for people and livestock in farming communities). The farmers are responsible for maintaining these small schemes. The PIU's are helped by financial and technical assistance from donor agencies.

Protection of Drinking Water Supplies

The Ministry of Water Development may declare drinking water catchment areas as protected areas. Within a protected catchment area, the Ministry can regulate all activities, including agricultural activities, to protect the water supply.

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Author: Gary Vocke

Demographics

Population	26.2 million (1992)
Population growth rate	3.6% per year (1992)
Population density	46 per square km (1992)
Urban population	24% of total population (1990)
Urban growth rate	7.9% per year (1980-90)

Economics

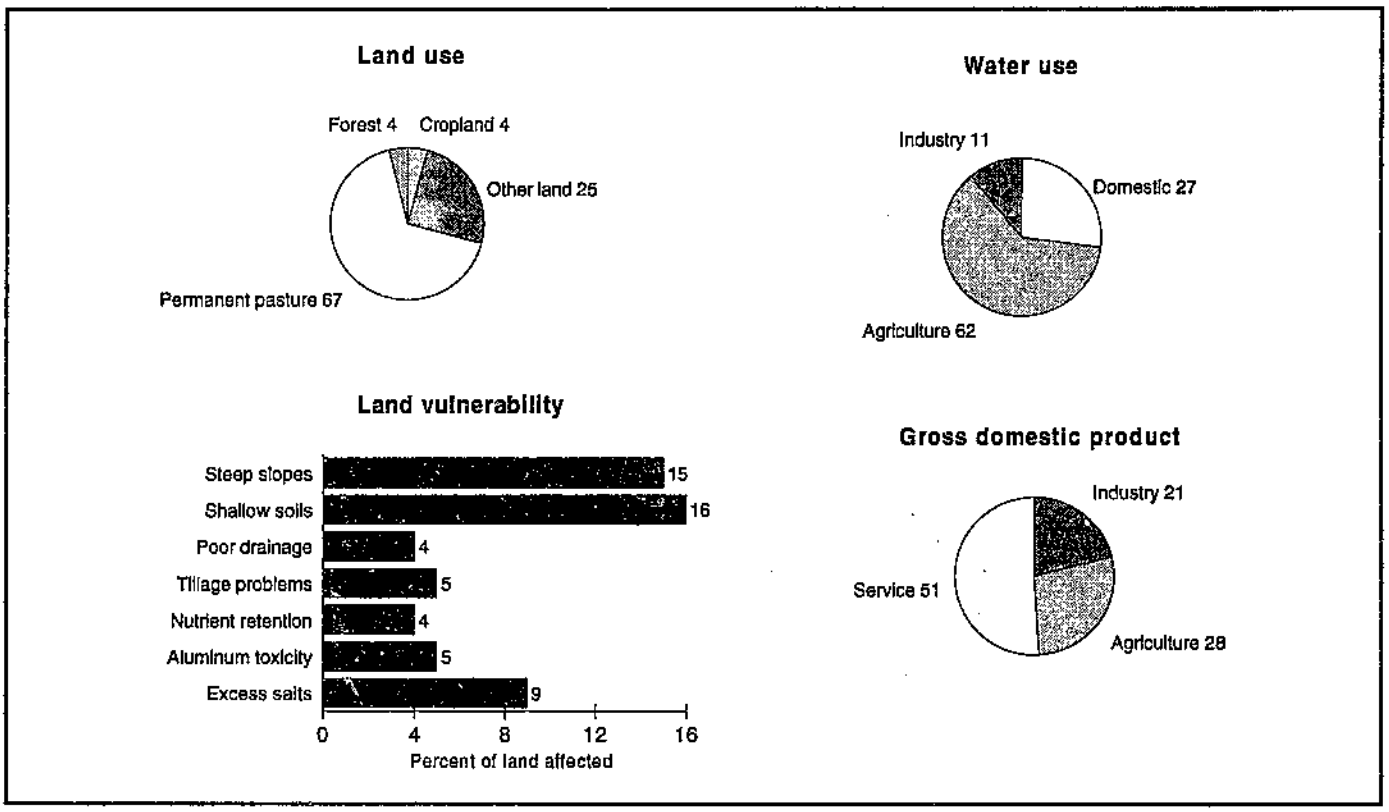
Gross domestic product	$7,540 million (1990)
GDP growth rate	4.2% per year (1980-90)
GDP per capita	$312 (1990)
Total external debt	81.2% of GNP (1990)

Environment

Land area	569,250 square km
Irrigated land	2% of cropland (1987-89)
Average fertilizer use	47 kg/ha cropland (1987-89)
Average pesticide use	1,307 metric tons active ingredient (1982-84)
Livestock contribution to methane	590,000 metric tons (1989)
Wet rice contribution to methane	8,000 metric tons (1989)
Greenhouse gas emissions	21 million tons CO_2 equivalent
Greenhouse gas emissions per capita	0.9 tons CO_2 equivalent
Land protected	5.8% of total land (1990)
Number of known threatened animal species	35 (1990)

Climate: varies from tropical along coast to arid in interior.

Environmental problems: unique physiography supports abundant and varied wildlife of scientific and economic value; deforestation; soil erosion; desertification; glaciers on Mt. Kenya; water pollution.



Mexico

The 1917 Constitution makes all water resources public property to be controlled by the Federal Government. Water rights are granted by the Government for not more than 50 years and these rights can be revoked if the use of the water is changed. Mexico's water allocation priorities are (1) domestic use, (2) public services, (3) livestock needs, (4) irrigation, (5) industry (power generation for public purposes first and other industries thereafter), (6) power generation for private purposes, and (7) drainage. All priorities, except domestic use, are subject to change by the Government.

Irrigation is by far the country's largest water user because more than 40 percent of its arable land requires irrigation to be farmed. Projected rapid growth of nonagricultural demands is expected to lead to acute conflicts among water users, especially in the overpopulated central highlands.

Central Government Is Heavily Involved in Irrigation

The National Water Commission (NWC) was created in 1989 and is the only institution authorized to manage the country's water resources. The NWC is principally involved in the country's irrigation through its irrigation districts and irrigation units, the two major types of irrigation entities in Mexico.

Public irrigation systems that are greater than 3,000 ha are called irrigation districts. Irrigation districts include 60 percent of the total irrigated area of the country. Public irrigation schemes smaller than 3,000 ha are called irrigation units. These small-scale, public schemes account for 30 percent of the irrigated area. The remaining 10 percent of the country's irrigated area is under small-scale schemes developed by the private sector.

Irrigation districts were a part of the country's national land redistribution program. In many instances, landless peasants were brought in to populate an area the Government had bought or expropriated. In these irrigation districts, the Federal Government constructed dams and canals for irrigation without charge to the farmers. These facilities remain the property of the Federal Government and are under the management of the NWC.

Farmers have little influence over the management of irrigation districts. Each district is controlled by a committee that is supervised by the Federal Government. Committee allocations of water to individual farmers are supposed to reflect the water requirements of the crop being grown. In many cases, the Government decides what crop will be grown. This management of districts by the Government is expected, under the current national policy of decentralization, to transfer to the farmers' water-user associations.

The Government assists with the design and planning of irrigation units. In contrast to irrigation districts, farmers in irrigation units have to contribute about 40 percent of the construction cost, mostly in the form of labor, and the Federal Government finances the remainder of the cost. Upon completion, the farmers become owners of these facilities. Irrigation units are operated and maintained by farmers through their water user associations, with some supervision by the Government. Farmers bear all the operation and maintenance costs.

Farmers in the irrigation districts and units are allowed to use groundwater to supplement their allocation of surface water for irrigation. The Government encourages this pumping by providing subsidized electricity. Pumping has increased so much that there is serious groundwater depletion in several northern areas and saltwater intrusion in coastal aquifers in the northwest.

There has been inadequate investment in drainage infrastructure in the irrigated areas, resulting in rising water tables and subsequent soil salinity problems. An estimated 10 percent of the irrigated lands have salinity problems.

Government Support to Irrigation Declines

Public investment policy from the 1950's to the 1970's favored irrigated agriculture (which includes only about 15 percent of the country's farmers). Nearly 90 percent of public expenditures for agriculture went for investment or operating costs in irrigated areas. The Government's policy was focused on expanding the area irrigated for social development objectives. In addition, much of the country's agricultural research was focused on irrigated agriculture. The result was that irrigated farming was responsible for much of Mexico's agricultural productivity gains.

The rapid expansion of irrigated lands came to a near halt with the financial crisis that started in 1982. This financial crisis also caused the Government to reduce its expenditures for operation and maintenance in the irrigation districts. This decline in Federal expenditures, in combination with the low water charges to farmers, resulted in insufficient revenue to maintain the irrigation systems. Irrigation efficiency has decreased.

Boundary Water Agreements

Mexico has three international rivers. The Rio Grande and the Colorado are shared with the United States and the Usumacinta with Guatemala. The Usumacinta River has a large potential for hydropower for Mexico. This potential will be developed within the framework of a treaty with Guatemala since more than one-third of the river's watershed is in Guatemala.

Boundary water issues between Mexico and United States have been resolved in a series of treaties, including the International Boundary and Water Commission, United States and Mexico, established in 1889. The treaty of 1906 apportioned the water between the two countries in the upper Rio Grande. A 1932 agreement was a joint plan for flood control works in the lower Rio Grande. The 1933 Convention was for joint works to stabilize the Rio Grande as a boundary river and control floods in the upper Rio Grande. The 1944 Water Treaty apportioned water in the lower Rio Grande and the water of the Colorado River between the two countries. Mexico exports a mean annual volume of 454 hm^3 (hectare-meters) on the Rio Grande and imports 1,856 hm^3 on the Colorado. A 1965 agreement was made to improve the salinity of the lower Rio Grande. A 1973 agreement was made to improve the salinity of the lower Colorado River.

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Authors: Julie Hopenfeld and Gary Vocke

Demographics

Population	92.4 million (1992)
Population growth rate	2.3% per year (1992)
Population density	48 per square km (1992)
Urban population	73% of total population (1990)
Urban growth rate	2.9% per year (1980-90)

Economics

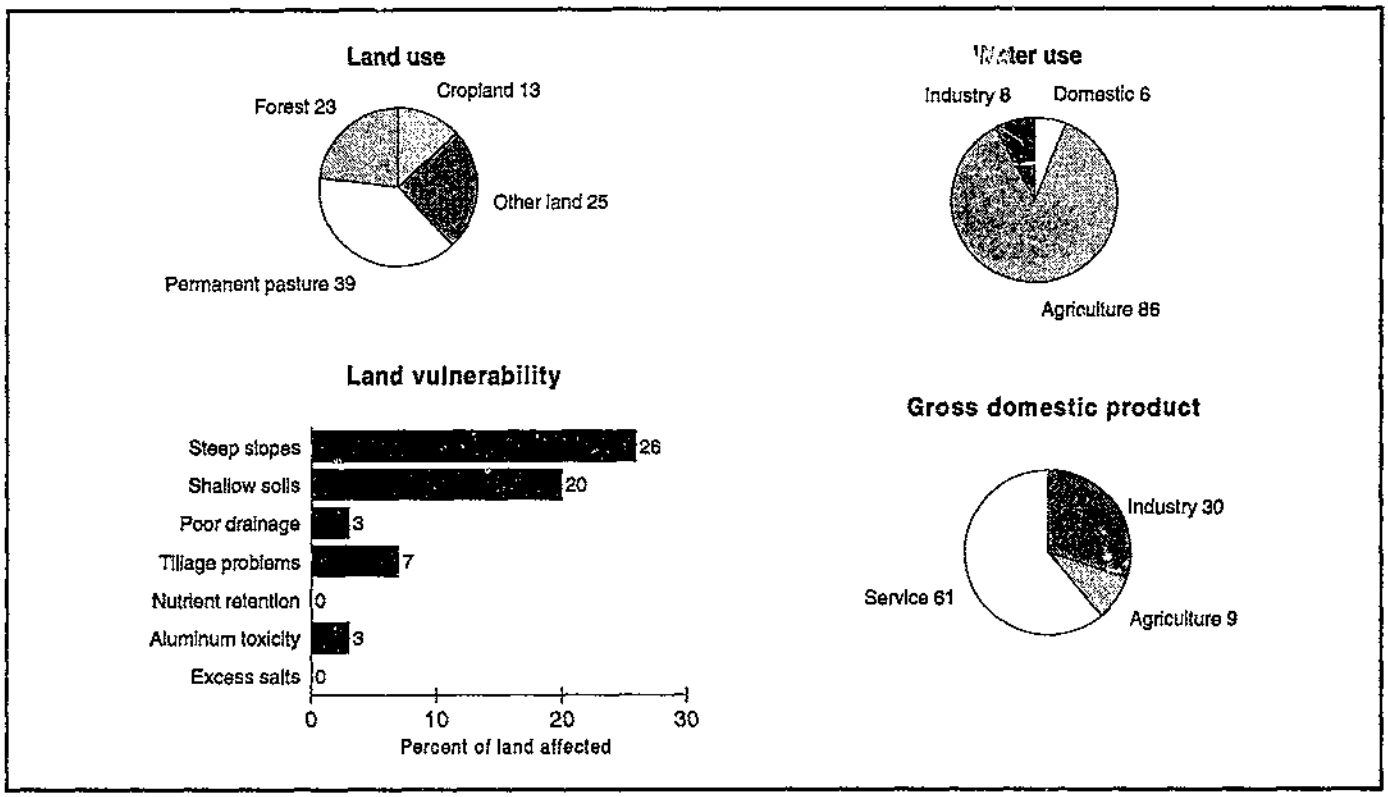
Gross domestic product	$237,750 million (1990)
GDP growth rate	1.0% per year (1980-90)
GDP per capita	$2,758 (1990)
Total external debt	42.1% of GNP (1990)

Environment

Land area	1,923,040 square km
Irrigated land	21% of cropland (1987-89)
Average fertilizer use	73 kg/ha cropland (1987-89)
Average pesticide use	27,630 metric tons active ingredient (1982-84)
Livestock contribution to methane	1,300,000 metric tons (1989)
Wet rice contribution to methane	30,000 metric tons (1989)
Greenhouse gas emissions	490 million tons CO_2 equivalent
Greenhouse gas emissions per capita	5.9 tons CO_2 equivalent
Land protected	4.8% of total land (1990)
Number of known threatened animal species	179 (1990)

Climate: varies from tropical to desert.

Environmental problems: subject to tsunamis along the Pacific Coast and destructive earthquakes in the center and south; natural water resources scarce and polluted in north, inaccessible and poor quality in center and southeast; deforestation; widespread erosion; desertification; serious air pollution in Mexico City and urban centers along U.S.-Mexico border.



Netherlands

Concern about contamination of drinking water and about nutrient enrichment of fresh and marine waters led to the National Environmental Policy Plan (NEPP) of 1989. Important objectives in the plan for the year 2000 affecting agriculture include a 90-percent reduction in nitrate and phosphate effluent disposal, a 70-percent reduction in ammonia emissions, a 50-percent cut in the use of pesticides, construction of plants for processing excess manure, and intensification of research on sustainable agricultural methods. These large adjustments targeted for agriculture in the NEPP reflect serious water pollution problems resulting from the dense livestock populations and intensive use of fertilizers and pesticides for crop production.

Water Management Institutions

The Ministry of Transport and Public Works is directly involved in managing the largest surface water bodies, and has a supervisory role over local management of other surface waters and groundwater resources. The Ministry can give permission to discharge polluted water in the water bodies under its control and can charge the polluters. The Ministry also finances the construction, operation, and maintenance of major waterworks.

Provinces are responsible for the surface water bodies not managed by the Central Government and all groundwater. Most Provinces have delegated their water quantity and quality management tasks to local water boards. Extraction of surface and groundwater by private individuals beyond quantity limits set by each Province requires a permit from a water board (except for agricultural withdrawals, including irrigation).

The governing bodies of the water boards are selected through interest group elections, not general elections. The founding articles for a water board define the interest groups (for example, owners of land, waste water dischargers, etc.) and the number of elected individuals from each interest group. The people in each interest group then elect their own representatives. Water boards are generally self-supporting because they can charge for the services provided.

Water Legislation

The Pollution of Surface Waters Act was first enacted in 1970 and has been modified over the years. Its main objective is pollution control of surface waters. The Act prescribes the permitting for discharging wastewater and the levying of charges on wastewater discharge. The Act states that the charges are only to recover the costs for wastewater treatment; additional charges to discourage the discharge of wastewater are prohibited.

The Groundwater Act of 1983 requires all Provinces to develop management plans and rules for issuing permits and levying charges on groundwater extraction. A request for a permit to extract groundwater is evaluated with respect to this Provincial groundwater plan. The Groundwater Act of 1983 is generally concerned with water quantity.

Controls on Agricultural Activities To Protect Water Quality

In recent years, manure from intensive livestock production on many farms has exceeded the capacity of the farm's land to safely recycle the nutrients for crop production. Environmental problems related to the disposal of this surplus manure can be grouped into three categories: (1) phosphate emissions to surface water, (2) nitrate pollution of groundwater, and (3) acidification by ammonia emissions.

The principal legislation to deal with these problems is the Soil Protection Act and the Manure Act. These Acts are national legislation with no regional differentiation. The Manure Act regulates the disposal of manure. The Soil Protection Act regulates the use of manure.

The Manure Act prohibits expanding animal production if the expansion results in the production of more than 125 kg of phosphate per year per hectare on agricultural land belonging to the farm. This Act also has some financial measures. There is a levy on feed to raise funds for research related to solving the problem of manure surpluses. A manure surplus levy is imposed on farms that produce manure above a predetermined amount. This levy is to meet the costs of manure banks, facilities for processing surplus manure into fertilizer pellets that can be sold, and for surveillance and searches. Finally, the Manure Act regulates manure storage facilities.

Under the Soil Protection Act, the Government establishes manure-application rate standards for manure disposal. Farmers are forbidden to apply more manure per hectare per year than the standard, expressed in kg of phosphates. The standard becomes

more severe over time, reaching its intended target in 2000. Farmers are not allowed to dump manure on their land between October 1 and March 1, which implies that no manure disposal is allowed outside of the growing season. Furthermore, farmers are required to plow the manure into their land within 48 hours after application to prevent volatilization of ammonia.

The Soil Protection Act also covers wellhead protection areas (WHPA's). The Act makes the Provinces responsible for enforcing regulations developed by the national waterworks association for the WHPA's. The regulation of agricultural activities in WHPA's is defined by underground water travel-time to the pumping station. In 1-year travel-time zones, the Government encourages water supply companies to purchase the land and then lease it to farmers with strict conditions on how it can be used. The companies generally do not buy the land in the 10- and 25-year zones, but they are responsible for compensating farmers in the 10- and 25-year zones for losses suffered as a consequence of the restrictions on their activities beyond what is required under national rules for agricultural practices.

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Authors: Jac C. Heckelman and Gary Vocke

Demographics

Population	15.1 million (1992)
Population growth rate	0.6% per year (1992)
Population density	446 per square km (1992)
Urban population	89% of total population (1990)
Urban growth rate	0.5% per year (1980-90)

Economics

Gross domestic product	$279,150 million (1990)
GDP growth rate	1.9% per year (1980-90)
GDP per capita	$18,735 (1990)

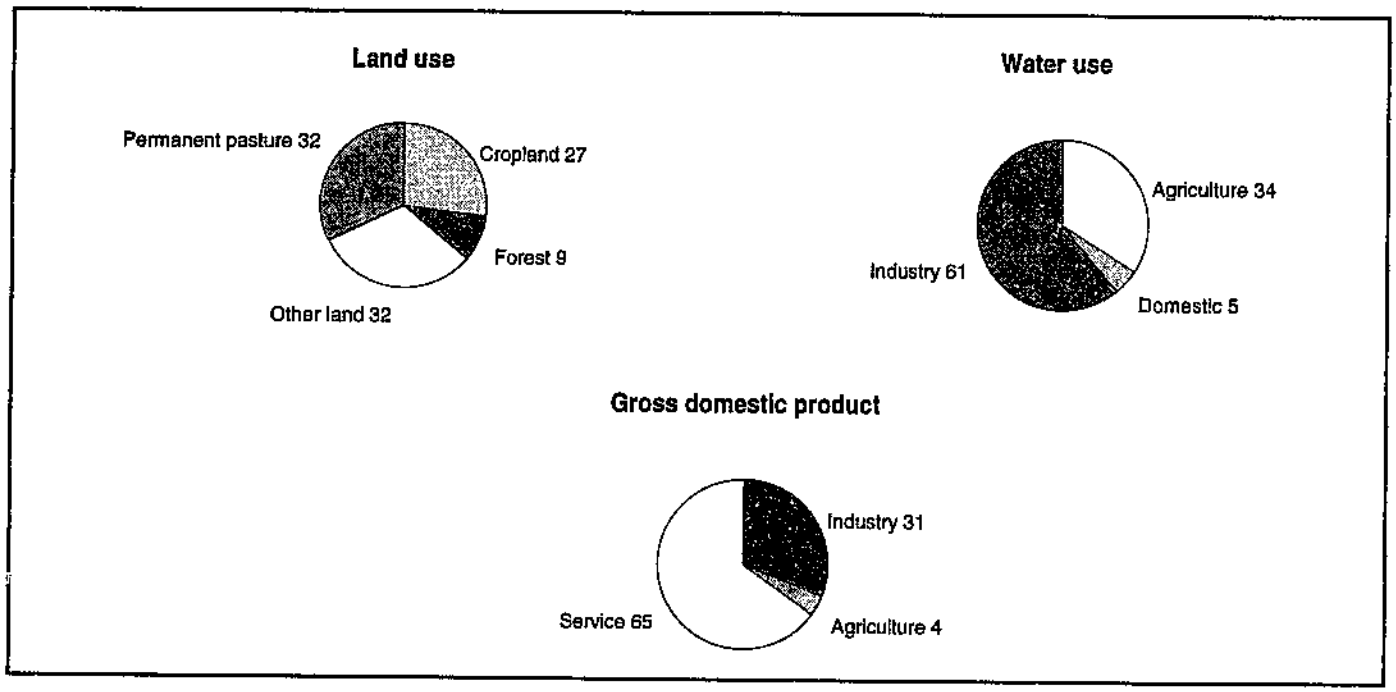
Environment

Land area	33,920 square km
Irrigated land	58% of cropland (1987-89)
Average fertilizer use	662 kg/ha cropland (1987-89)
Average pesticide use	9,670 metric tons active ingredient (1982-84)
Livestock contribution to methane	260,000 metric tons (1989)
Wet rice contribution to methane	NA
Greenhouse gas emissions	170 million tons CO_2 equivalent
Greenhouse gas emissions per capita	11.5 tons CO_2 equivalent
Land protected	9.5% of total land (1990)
Number of known threatened animal species	16 (1990)

Climate: temperate; marine; cool summers and mild winters.

Environmental problems: 27% of the land area is below sea level and protected from the North Sea by dikes; water pollution; air pollution; drinking water contamination; noise pollution.

NA = Not available/applicable.



Nigeria

Nigeria has relatively abundant water supplies relative to demands. There has not been any serious competition for the use of water among alternative uses. Most of agriculture's use of water is by small-scale, informal irrigation schemes without any government involvement.

Legislated and Customary Laws

There are two types of water laws in Nigeria: the legislated water laws and the traditional, customary water laws. The basis for the water law legislation is the Consitution, which places responsibility for developing and regulating water resources with the States. Interstate and international waters, however, are the responsibility of the National Government. Most States have enacted new water legislation since independence and have created an agency to regulate the development and use of water. Some States, however, are still following the old national Waterworks Law of 1915 (as amended in 1944), which was enacted under British rule.

Under Nigerian customary laws, water supplies are usually considered communal property. Generally, no member of the community can claim sole ownership of a source of water, even if the source is strictly within an individual's land. Every member of the community, except those suffering from contagious or chronic disease, has a right to water for both household and agricultural use. An exception to this rule can sometimes occur when landowners dig wells on their own land for their use only.

Under customary law, when a stream or river flows through several communities, each community has riparian rights to the water. Diversion of a river by one community that harms another community's water supply from that river is regarded as a hostile act. Each community is responsible for protecting the water supply from pollution, and polluters can be brought before the community leaders and fined.

Public Sector Irrigation

There are three public sector agencies responsible for irrigation infrastructure development in Nigeria. The State Ministry of Agriculture and Rural Development provides credit to small-scale farmers (less than 50 hectares) for constructing boreholes and shallow tubewells and for purchasing pumps. The Ministry also constructs medium-scale irrigation systems (50-2,000 hectares). A second agency, the Directorate of Foods, Roads and Rural Infrastructure, is responsible for small-scale, village-based irrigation system development and also potable water schemes.

A third agency, River Basin Development Authorities (RBDA), is responsible for the construction and management of the large-scale irrigation systems (2,000 or more hectares). The role of the RBDA is changing following the adoption in 1987 of a new policy of commercialization and privatization. This policy reform is changing the legal system of irrigation management, the role of users' organizations, the collection of water charges, and the sharing of responsibilities between RBDA and the farmers. The cost of services provided by the RBDA will no longer be subsidized, but will be borne by the beneficiaries. The Government will still provide funds for the construction of the infrastructure. The completed irrigation systems, however, will have to generate funds for operation and maintenance.

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Authors: Rachel Wallace and Gary Vocke

Demographics

Population	126.3 million (1992)
Population growth rate	3.0% per year (1992)
Population density	139 per square km (1992)
Urban population	35% of total population (1990)
Urban growth rate	6.0% per year (1980-90)

Economics

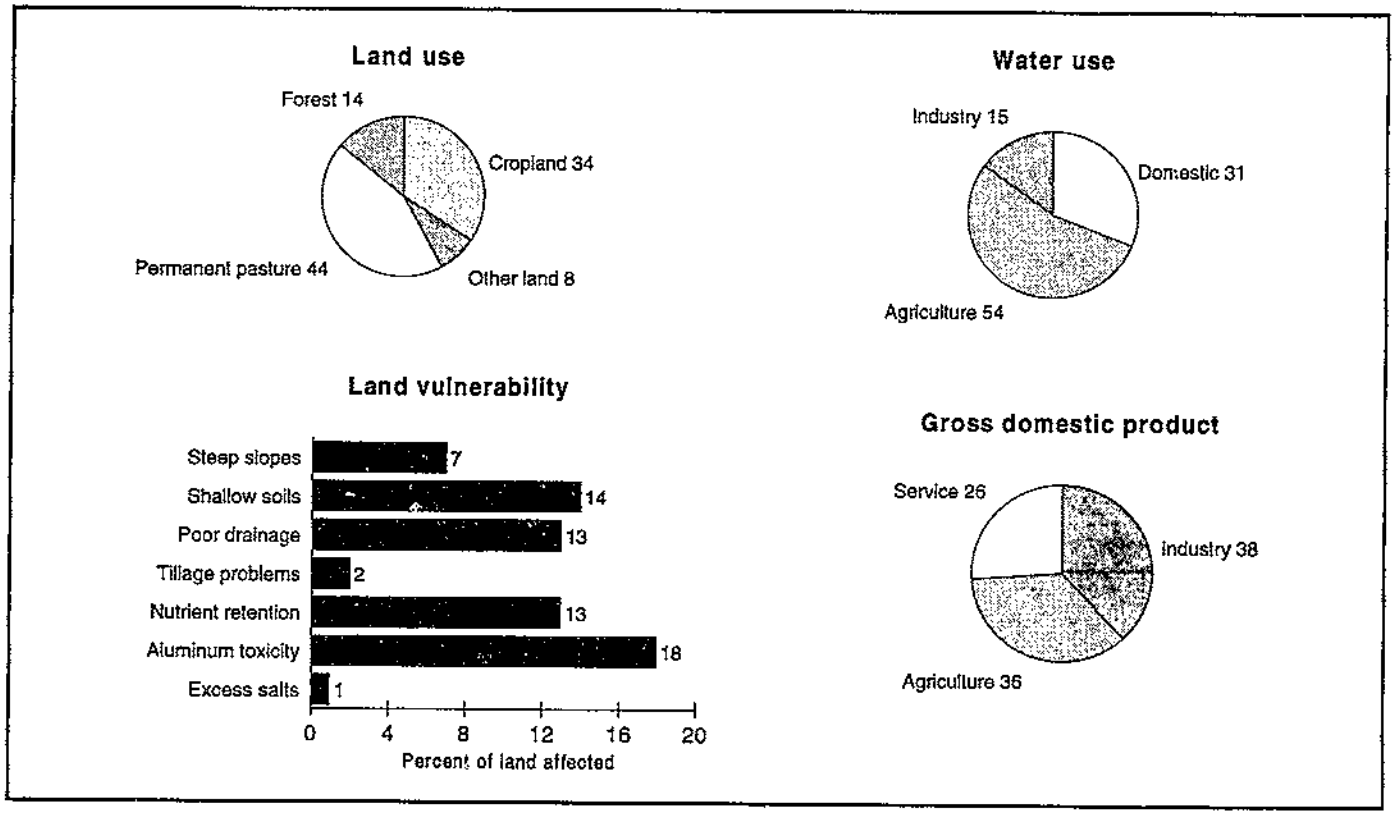
Gross domestic product	$34,760 million (1990)
GDP growth rate	1.4% per year (1980-90)
GDP per capita	$301 (1990)
Total external debt	110.9% of GNP (1990)

Environment

Land area	910,770 square km
Irrigated land	3% of cropland (1987-89)
Average fertilizer use	10 kg/ha cropland (1987-89)
Average pesticide use	4,000 metric tons active ingredient (1982-84)
Livestock contribution to methane	630,000 metric tons (1989)
Wet rice contribution to methane	140,000 metric tons (1989)
Greenhouse gas emissions	352 million tons CO_2 equivalent
Greenhouse gas emissions per capita	3.2 tons CO_2 equivalent
Land protected	1.7% of total land (1990)
Number of known threatened animal species	37 (1990)

Climate: varies - equatorial in south, tropical in center, and arid in north.

Environmental problems: recent droughts in north severely affecting marginal agricultural activities; desertification; soil degradation; rapid deforestation; water contamination.



Pakistan

Upon Independence in 1947, Pakistan inherited from British India a legal system where water management was mainly the responsibility of the Provinces. Under Pakistan's Constitution, Provincial governments are able to plan and execute only those projects that do not interfere in any way with the water rights of other Provinces. For interprovince projects, the Federal Government's Ministry of Water and Power is responsible for coordinating planning and development. This Ministry is involved with all projects using foreign technical or financial assistance.

The key event regarding surface water supplies in Pakistan was the resolution of its water dispute with India through the Indus Basin Treaty of 1960. When the partition of British India gave to India the headwaters of the Indus river system and some of the major diversion structures that serve large irrigated areas in Pakistan, controversy arose regarding division of the waters between the two countries. The controversy led to armed conflict. The Indus Basin Treaty resolved the conflict by allocating the waters of the eastern rivers in the Indus Basin to India and the western rivers to Pakistan. The Treaty also included provisions to increase the supply of water in the Indus Basin.

Canal Irrigation

Ninety percent of agricultural production in Pakistan comes from irrigated lands. The regulations governing the irrigation system that supplies the water to these lands are set forth in the Canal and Drainage Act of 1873, the Sindh Irrigation Act of 1879, and the Punjab Minor Canals Act of 1905. These regulations apply to surface water facilities and specify how water is to be delivered in the country's publicly managed irrigation schemes. Responsibility for carrying out the regulations rests with the Provincial Irrigation Departments.

Provincial governments are responsible for the operation and maintenance of this canal system up to the outlet to the farmers' watercourses. Within a watercourse command, each irrigator receives a supply of water proportionate to their landholdings. This allocation is accomplished by giving the entire flow of the watercourse to one farm for a specified time period on a 7-day rotation. If the irrigators cannot agree what the rotation schedule will be, the Provincial Irrigation Department will establish a rotation for the farmers. The Government is now attempting to foster the development of water user associations for the management of canal water. These associations are organized and registered under the Water Users Associations Ordinance of 1981.

Problems with the Public Irrigation System

The public canal system is in need of renovation, partly due to age and partly due to poor or deferred maintenance. Revenue to the Provincial governments from water charges is insufficient to cover operation and maintenance expenses. Thus, Provinces have to use their general budgets to finance part of these expenses. Often the needed funds are unavailable, so maintenance is inadequate.

Pakistan has developed significant salinization and waterlogging problems in its irrigated areas because its irrigation systems were designed without adequate drainage facilities. To combat these problems, the Ministry of Water and Power began developing tubewells in the 1950's. Pumping with the tubewells lowered the water table, reversing the salinization and waterlogging. Later, farmers began developing their own tubewells to supplement canal-supplied water. Now, groundwater development is mainly by privately owned tubewells.

Farmers were motivated to develop these wells because only about 60 percent of the canals have water year-round. The rest of the irrigated area receives water only during the summer when there is a higher flow in the rivers. Consequently, many farmers have constructed tubewells to offset inadequate and unreliable deliveries of canal water. Presently, about 70 percent of the private tubewells in the country are located in the public canal command areas. This expansion of private tubewell pumping of groundwater has been the source of the country's increased water supplies for irrigation in recent years; surface water supplies are already fully exploited. It has been government policy to encourage private tubewell installations through subsidies. Farmers developing these private wells can sell excess water from their tubewells to neighbors.

In addition to promoting the development of tubewells, there is a Federal program to construct drainage works for the control of waterlogging and salinity in irrigated areas. Presently, about 40 percent of the Federal irrigation budget is for this drainage program. When these drainage works are completed, their operation and maintenance is the responsibility of the Provincial government.

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Author: Gary Vocke

Demographics

Population	121.7 million (1992)
Population growth rate	2.9% per year (1992)
Population density	156 per square km (1992)
Urban population	32% of total population (1990)
Urban growth rate	4.6% per year (1980-90)

Economics

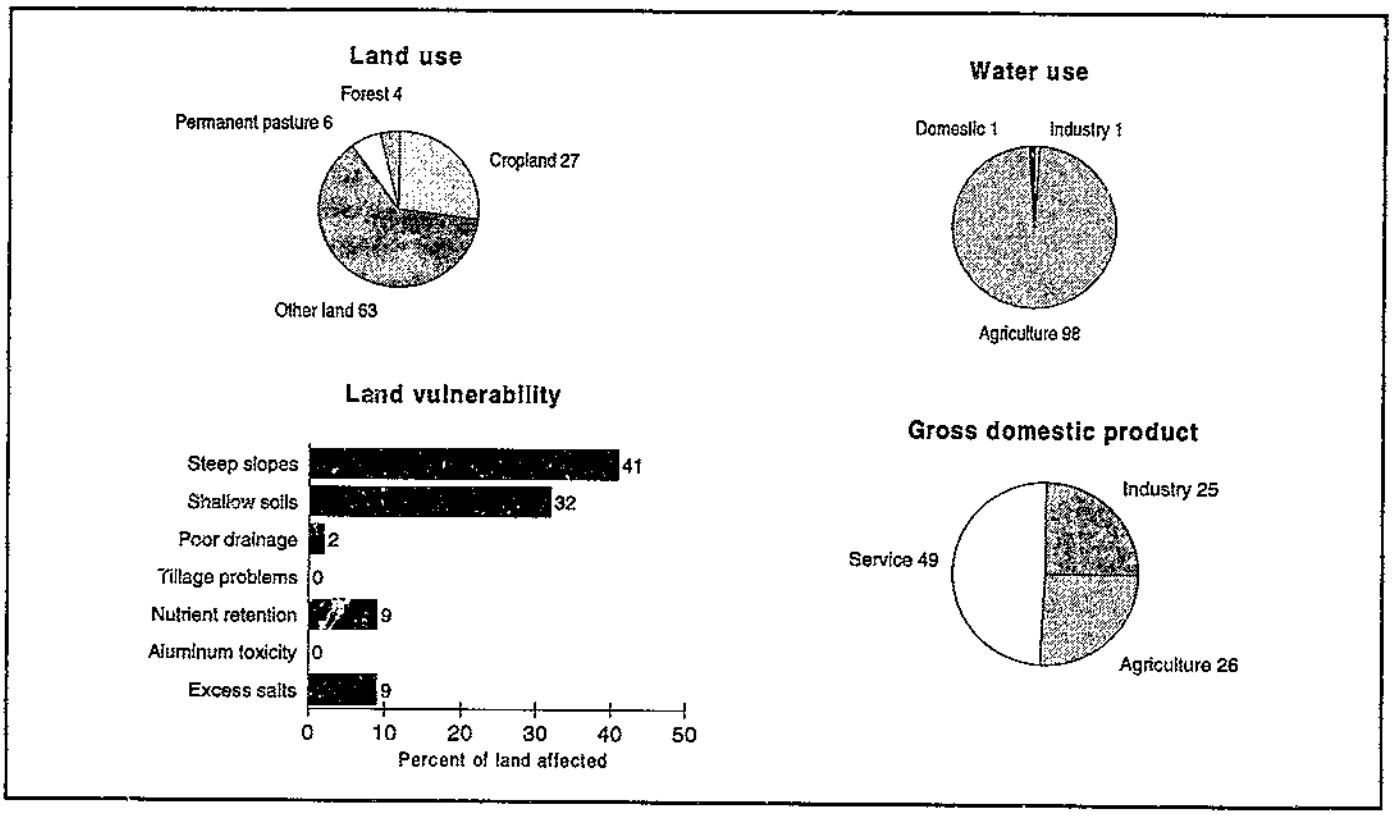
Gross domestic product	$35,500 million (1990)
GDP growth rate	6.3% per year (1980-90)
GDP per capita	$316 (1990)
Total external debt	52.1% of GNP (1990)

Environment

Land area	778,720 square km
Irrigated land	78% of cropland (1987-89)
Average fertilizer use	85 kg/ha cropland (1987-89)
Average pesticide use	1,856 metric tons active ingredient (1982-84)
Livestock contribution to methane	1,700,000 metric tons (1989)
Wet rice contribution to methane	1,100,000 metric tons (1989)
Greenhouse gas emissions	89 million tons CO_2 equivalent
Greenhouse gas emissions per capita	0.8 tons CO_2 equivalent
Land protected	4.6% of total land (1990)
Number of known threatened animal species	46 (1990)

Climate: mostly dry, hot desert; temperate in northwest; arctic in north.

Environmental problems: frequent earthquakes, occasionally severe especially in north and west; flooding along the Indus after heavy rains (July and August); deforestation; soil erosion; desertification; water logging; water pollution; water scarcity; coastal pollution.



South Africa

The Water Act of 1956 consolidated and amended the water laws in South Africa, a country with relatively scarce water resources. This Act provides for central control of the country's water resources while allowing for the decentralization of daily management of water usage and protection of water quality. In recognition of the rising industrial and urban water demands relative to agriculture, the Irrigation Department was renamed the Department of Water Affairs.

Classes of Water

Water is divided into two classes, private water and public water. Public water is defined in the 1956 Water Act as any water in a natural stream capable of common use for irrigation on two or more pieces of riparian land. There is no right of property in public water. Under the Water Act, the use of public water is restricted largely to riparian landowners.

Public water is divided into two parts, normal flow and surplus water, each with different regulations under the Water Act. Normal flow is that quantity of water derived from a permanent source that, without storage, can be used to irrigate riparian land. All water in a public stream other than normal flow is surplus water.

Private water includes spring water, rain water, drainage water, water of private streams, and underground water. The right to use private water belongs to the owner of the land on which the water is found and can be used as the owner wishes, including wasting it.

The use of treated sewage for irrigation has been practiced for many years. Water quality standards before use in irrigation are specified in the Water Act. The use of effluent for irrigation is not permitted on crops likely to be eaten raw.

Public Water Rights

Water rights attach to riparian land and these rights are acquired as soon as riparian land is acquired. All riparian landowners are entitled to a pro rata share of the normal flow, and upper riparian landowners do not have priority over lower ones. The landowners must not waste any water and must return as much of the water as reasonably possible to the stream after use.

As a general rule, domestic requirements must be satisfied along the entire public stream before any water can be used for irrigation; irrigation and domestic needs must be fully satisfied before any water can be used for industrial or mechanical purposes. In all cases, the extent of the use of normal flow by an individual landowner must be reasonable, except for domestic purposes, in which case it is permissible for a single riparian landowner to extract the entire flow. Reasonable use depends on the circumstances of each particular case. A permit is required from the Department of Water Affairs for water use above 60,000 gallons on any day or an average of 50,000 gallons per day during any month. When there is a drought, all irrigators must abate pro rata.

Every riparian landowner may use as much surplus water as can be beneficially used for domestic purposes, for watering livestock, and for other agricultural uses. In contrast with normal flow, no preference is given to domestic use. All the surplus water may be taken by a single upper riparian landowner. Because the riparian landowner who is higher on a public stream has the prior right to surplus water, a project for storing surplus water may be ruined by another dam subsequently built above it.

Water Court

Individuals may apply to the Water Court for relief if they believe their rights are being infringed. For example, lower riparian landowners who believe they have been harmed by an upper riparian landowner using an inordinate amount of surplus water may apply to the Water Court for a determination of the amount that can reasonably be used. When it is not clear how much water a riparian landowner can reasonably extract, an interested person may apply to the Water Court that the rights be investigated, apportioned, and recorded. Such a declaration is binding on all users affected by it. Unless there has been a lawful distribution of the normal flow by court apportionment or by agreement, normal flow cannot be stored in a dam for storing surplus water.

The Water Court has wide authority over the use of water by nonriparian owners. A potential, nonriparian user wishing to gain access to a public stream to extract water may serve a written notice to the riparian landowner specifying the intent and suggested compensation. If the riparian landowner does not agree, the claimant may submit the request to the

Water Court. The potential nonriparian user must show that the proposed use will be in the public interest or that the water is not being used. The Water Court may authorize use on nonriparian land for a period of years fixed by the Court or permanently.

All industrial use must be approved by the Water Court. The Water Court may give approval only if the industrial use is in the public interest or if the water is not being used. The Department of Water Affairs, however, may supply water from any government-constructed waterworks to anyone for use at any place and for any purpose. In certain circumstances, local authorities are also exempted from Water Court approval.

Government Controls

The Government may declare any area a Government Control Area and adjoining land to be a Catchment Control Area to ensure high-quality water supplies. In such Control Areas, the Department of Water Affairs has wide powers of abating rights of riparian owners and giving nonriparian owners rights. Land or water rights may be expropriated in Control Areas with compensation to the landowner. Fair compensation is determined by the Water Court.

The Water Act allows the establishment of Irrigation Boards to protect the sources of public streams, prevent waste, prevent unlawful abstraction, and regulate the use of public water. These Boards allow some measure of local administration, and are usually formed to establish a communal scheme of water distribution among riparian owners. It is customary for the State to subsidize one-third of the cost of works approved by the Department of Water Affairs. As with other Control Areas, an Irrigation Board has no power to alter water rights unless it pays compensation.

Generally, the Water Act does not inhibit the development and use of private water. However, the Government can create Subterranean State Groundwater Control Areas if regulation of groundwater extraction is determined to be in the national interest. In these areas, groundwater extraction is controlled through a permitting system.

The Water Act also provides for decentralization of water management through the creation of Water Boards. These Boards are corporate bodies that construct or manage government-financed waterworks to supply water for agricultural, urban, and industrial uses. A Board may not take or use any water to which it does not have a right.

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Authors: Rachel Wallace and Gary Vocke

Demographics

Population	41.7 million (1992)
Population growth rate	2.6% per year (1992)
Population density	34 per square km (1992)
Urban population	60% of total population (1990)
Urban growth rate	3.7% per year (1980-90)

Economics

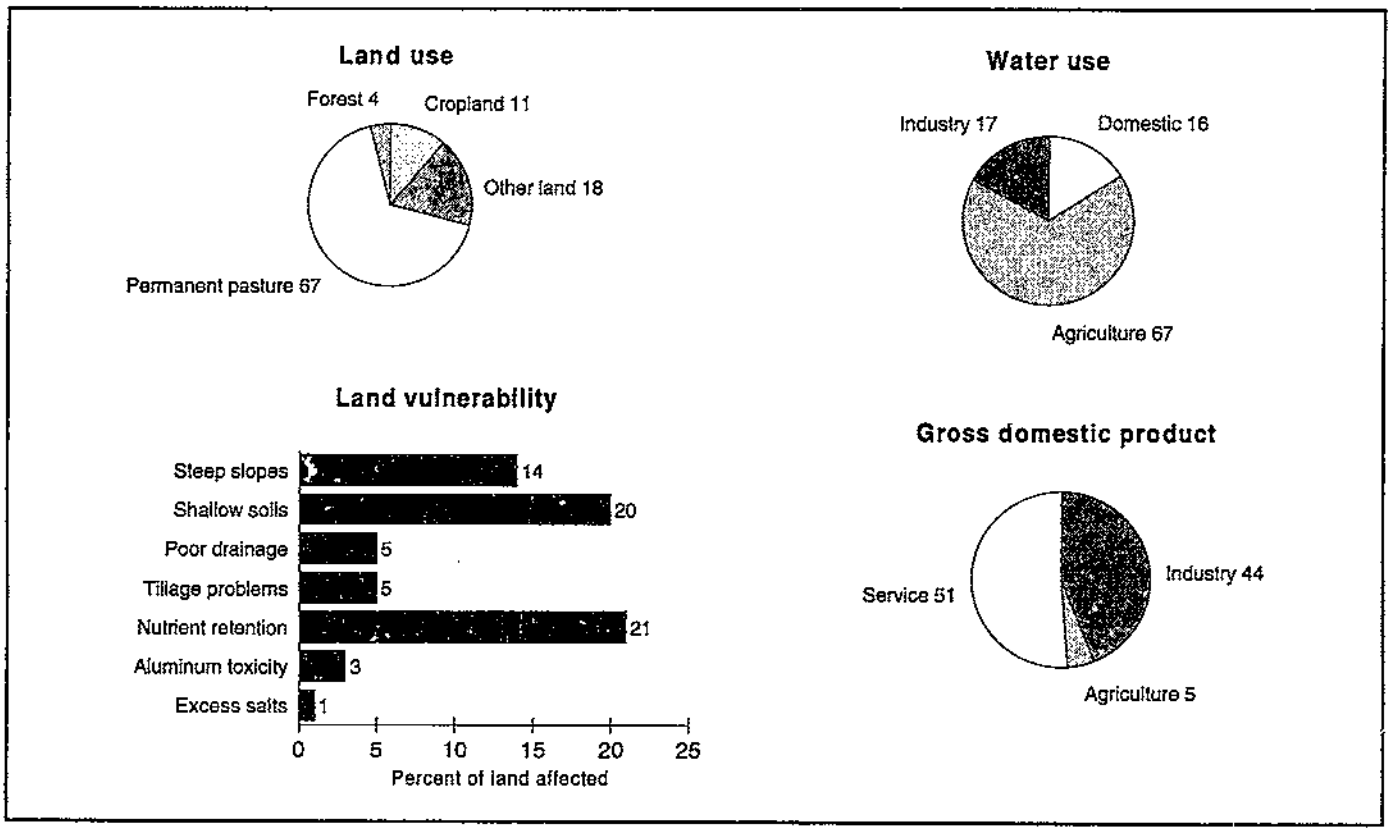
Gross domestic product	$90,720 million (1990)
GDP growth rate	1.3% per year (1980-90)
GDP per capita	$2,527 (1990)

Environment

Land area	1,221,040 square km
Irrigated land	9% of cropland (1987-89)
Average fertilizer use	58 kg/ha cropland (1987-89)
Average pesticide use	11,053 metric tons active ingredient (1982-84)
Livestock contribution to methane	820,000 metric tons (1989)
Wet rice contribution to methane	1,000 metric tons (1989)
Greenhouse gas emissions	282 million tons CO_2 equivalent
Greenhouse gas emissions per capita	8.3 tons CO_2 equivalent
Land protected	5.2% of total land (1990)
Number of known threatened animal species	71 (1990)

Climate: mostly semiarid; subtropical along coast; sunny days, cool nights.

Environmental problems: lack of important arterial rivers or lakes requires extensive water conservation and control measures; soil erosion; air pollution; desertification.



Spain

In 1985, Spain passed a new Water Law placing all water into the public domain. Under the old water law, only surface water was in the public domain. With the new law, existing owners of underground water had two choices. They could maintain ownership of their water for 50 years and then receive an automatic concession from the Government for an additional 75 years. Or they could retain their ownership if their future use was the same as in the past. If they changed the usage of their water, they would immediately become a concessionaire to the Government.

Public domain water is managed for the Government by 12 basin agencies under the Ministry of Public Works. Generally, the use of water requires a concession from a basin agency. However, if a well pumps less than 5,000 m^3 per year, authorization is not required.

Irrigation Management

Irrigators form water communities for the management of water for irrigation. Any irrigation system having more than 20 owners or more than 200 hectares must form a water community. These communities have the legal power to impose fines, to assess taxes to cover operating costs, and to approve ordinances. Normally, at least one member of the Board of Directors is from the area most distant from the main intake, where less water might be received or there might be drainage or salinity problems. This practice ensures that the Board membership represent those interests that are likely to have difficulties if the system is mismanaged.

Water communities are relatively independent organizations with no fixed way of conducting business. In some communities, every member has just one vote. In others, large landholders are given more votes than small landowners. Some communities tie water rights to the land and allocate water to irrigators in proportion to their landholding in the irrigation scheme. Other communities have a water market where water rights can be sold between members. Communities also have different procedures for rationing water among members during severe droughts.

The law allows the construction of irrigation works through their water communities. If the petitioners for new or expanded waterworks are supported by half of the owners of the land affected, a concession can be issued by the basin agency. Granting a concession for expanding irrigation is limited to areas where irrigation's contribution to economic and social development is a national priority.

Water communities each have an irrigation jury. The jury members are elected by those in the water community. Judgments by the jury are oral, public, and immediately enforced.

Water Quality Problems

The country has problems with progressive salinization of intensely irrigated areas because of poor water management. Along the coast, there has been saltwater intrusion when groundwater has been overpumped. The resulting high salt levels in the underground water supplies have caused abandonment of some irrigated lands.

Administrative authorization is required for all activities likely to contaminate water. This authorization may be withdrawn if conditions imposed by the water authorities are not met. A fee is levied for discharges into water bodies. The level of the fee depends on the degree of pollution of the water body, as determined by the basin agency. These fees are used to finance activities to reduce water pollution in that water basin.

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Authors: Jac C. Heckelman and Gary Vocke

Demographics

Population	39.1 million (1992)
Population growth rate	0.2% per year (1992)
Population density	78 per square km (1992)
Urban population	78% of total population (1990)
Urban growth rate	1.1% per year (1980-90)

Economics

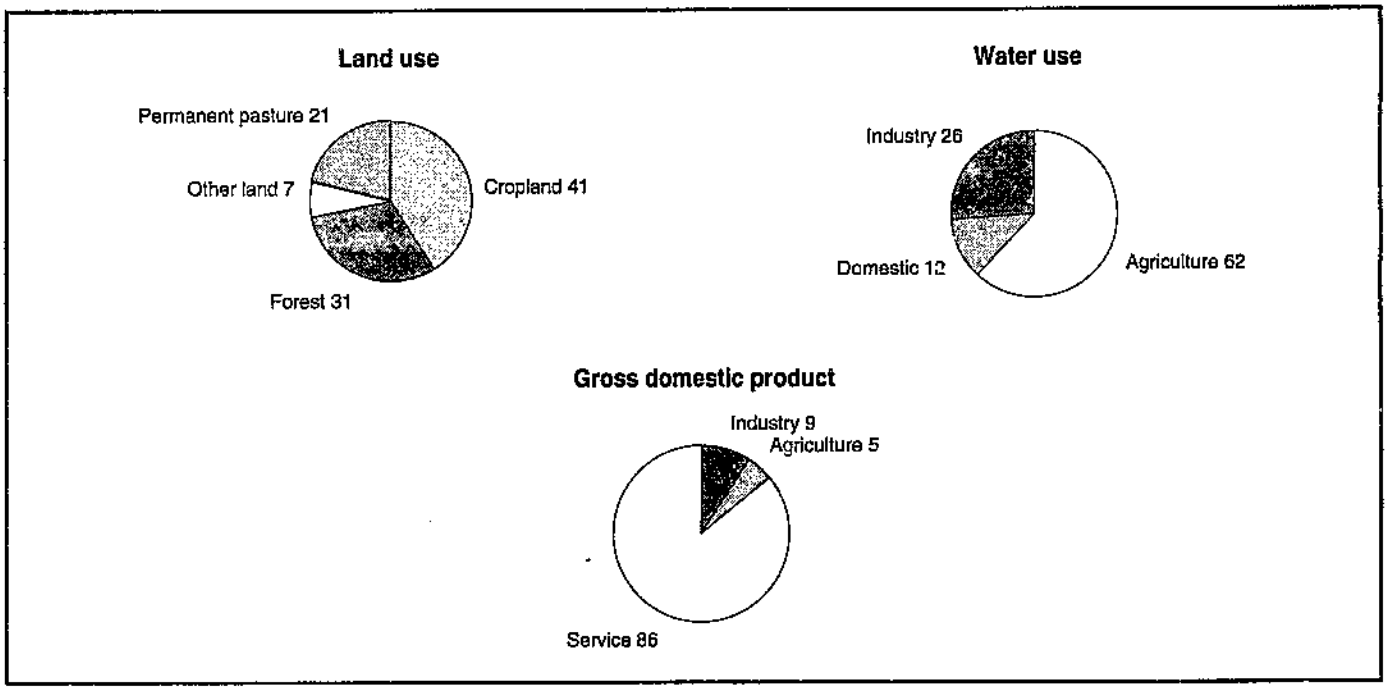
Gross domestic product	$491,240 million (1990)
GDP growth rate	3.1% per year (1980-90)
GDP per capita	$12,596 (1990)

Environment

Land area	499,400 square km
Irrigated land	16% of cropland (1987-89)
Average fertilizer use	101 kg/ha cropland (1987-89)
Average pesticide use	71,533 metric tons active ingredient (1982-84)
Livestock contribution to methane	520,000 metric tons (1989)
Wet rice contribution to methane	32,000 metric tons (1989)
Greenhouse gas emissions	330 million tons CO_2 equivalent
Greenhouse gas emissions per capita	8.5 tons CO_2 equivalent
Land protected	7.0% of total land (1990)
Number of known threatened animal species	39 (1990)

Climate: temperate; clear, hot summers in interior, more moderate and cloudy along coast; cloudy, cold winters in interior, partly cloudy and cool along coast.

Environmental problems: deforestation; air and water pollution; land degradation.



Sudan

Water policy in Sudan focuses on the Nile River and its tributaries. River Control Regulations regulate the use of water for hydropower, irrigation, and drinking water supply; downstream rights; and minimum acceptable flows. Irrigation Regulations govern the control and distribution of irrigation water and define the relationship between the water control authorities and the agricultural authorities in managing the large-scale irrigation projects. The Ministry of Irrigation (MOI) has the authority to enforce these Regulations.

No single agency has been given authority for overall, integrated multipurpose development of river basins in the country. Whenever the MOI or the National Electric Corporation undertakes a project on the Nile or on any of its tributaries, an interagency steering committee is set up. This interagency committee ensures that the interests of all water users are taken into consideration in the final formulation of projects.

Sudan's irrigated subsector includes large and small public irrigation schemes and private pump schemes. The private pump schemes are constructed and operated by the irrigators, with the Government having little involvement other than licensing the pumping of the water from the river.

Governmental Controls of Private Water Extraction

The Nile Water Control Board is the governmental authority that issues river-pumping licenses for irrigation in the Nile River area. The Board can specify conditions for individual licenses. The Board may refuse to renew a license or revoke a license at any time without giving a reason or compensation. A river-pumping license is transferable if the Board gives written consent. The annual fee set by the Board for pumping varies by type of license and size of pump.

The Board issues three types of river-pumping licenses: perennial, flood, and restricted. The holder of a perennial license can pump throughout the year. Under a flood license, pumping is restricted to July 16-December 31. A perennial or flood license last 10 years for pumps of 10 or fewer inches and 15 years for pumps greater than 10 inches. A restricted license is valid for only 1 year.

The Rural Water and Development Corporation is responsible for the development and use of groundwater resources. Written permission is required from the Corporation before a well can be constructed. The Corporation can specify restrictions and conditions to its permission to construct a well.

Management of Public Irrigation Projects

The MOI and parastatals under the Ministry of Agriculture manage the country's five large-scale irrigation projects. The MOI operates and maintains the irrigation infrastructure, and parastatals supply the production inputs and management services. Management services include determining what crops are to be planted and then purchasing those crops from farmers for marketing. The parastatal's payment to the farmer for the crop is adjusted for all input costs, including the cost of water.

The charges for the irrigation water are less than actual cost to the MOI and are paid to the Ministry of Finance and Economic Planning, not the MOI. The funds provided to the MOI from the Government's general budget have been inadequate to maintain the irrigation infrastructure, impairing the physical condition of the irrigation works.

There is a new policy to replace parastatal management on the smaller pump schemes. Farmers in these schemes decide by majority vote whether they will organize and manage their schemes directly or enter into contracts with private companies for management services.

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Author: Gary Vocke

Demographics

Population	28.3 million (1992)
Population growth rate	3.1% per year (1992)
Population density	11 per square km (1992)
Urban population	22% of total population (1990)
Urban growth rate	3.9% per year (1980-90)

Economics

Gross domestic product	$11,240 million (1988)
GDP growth rate	2.5% per year[1] (1980-88)
GDP per capita	$472[1] (1988)
Total external debt	74.6% of GNP[1] (1988)

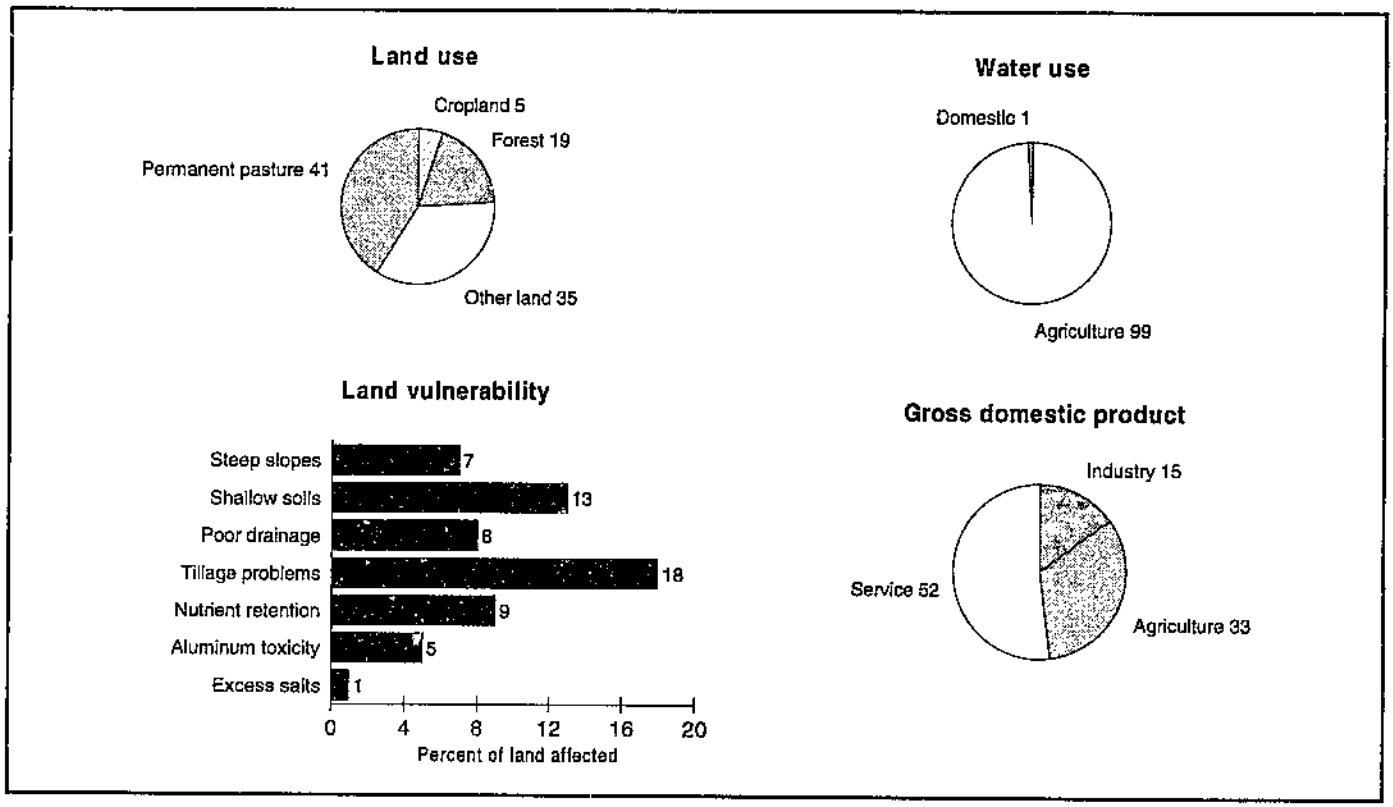
Environment

Land area	2,376,000 square km
Irrigated land	15% of cropland (1987-89)
Average fertilizer use	4 kg/ha cropland (1987-89)
Average pesticide use	NA
Livestock contribution to methane	1,100,000 metric tons (1989)
Wet rice contribution to methane	1,000 metric tons (1989)
Greenhouse gas emissions	95 million tons CO_2 equivalent
Greenhouse gas emissions per capita	4.0 tons CO_2 equivalent
Land protected	3.1% of total land (1990)
Number of known threatened animal species	26 (1990)

Climate: tropical in south; arid desert in north; rainy season (April - October).

Environmental problems: dominated by the Nile and its tributaries; dust storms; desertification; environmental health problems; loss of wildlife; susceptibility to plant and animal pests.

NA = Not available/applicable.



Thailand

Water management in Thailand has mostly been about generation of electrical power and irrigation development and management. Recently, however, demand for water in Bangkok and the southern Chao Phraya Basin is increasing with industrialization, urbanization, and dry-season rice production. This Basin occupies about one-third of the country. The southern part of the Basin relies on water released from several large hydroelectric dams in the north. There are now few opportunities to expand the water supply to meet these new demands. As the use of water for irrigation in the north increases, the quantity of water available for release is increasingly inadequate to supply the south's rising needs. In addition, freshwater flow has recently been inadequate to prevent salt water from backing up from the Gulf of Siam and intruding into the area's freshwater aquifers.

Thailand has little water-rights legislation to resolve this competition for available water supplies. There is, however, legislation concerning the planning, development, and operation of waterworks for irrigation, by far the largest user of water. The Government's Royal Irrigation Department (RID) of the Ministry of Agriculture and Cooperatives (MOAC) handles virtually all irrigation development in Thailand, except for numerous small private schemes in the north developed by farmer groups.

The planning process for an irrigation project depends on the size of the project. Planning of large-scale irrigation projects is a top-down process by the RID and requires the Cabinet's approval concerning its environmental effects. Planning of small-scale irrigation projects is a bottom-up process from the farmers to the Government.

The construction of storage dams has helped to compensate for the high flow of the monsoon rainfall in the wet season and has substantially increased the availability of water during the dry season. The surface water irrigation systems are continuous-flow systems designed for rice production.

Government-Managed Irrigation

The construction and operation of large multipurpose reservoirs that store water for irrigation is the responsibility of the Electric Ceneration Authority of Thailand. The large-scale irrigation facilities are the responsibility of RID. More than half of the annual budget of the MOAC goes to RID. About half of RID's budget is used for constructing new irrigation facilities, with the remainder used for operation, maintenance, and supporting services. RID organizes the farmers into water user groups to manage tertiary facilities. If the project includes land consolidation, the water user groups are the responsibility of the Cooperatives Promotion Department. Farmers in these land consolidation projects are expected to pay a proportion of the costs of such works under the 1974 Land Consolidation Act, and collection has begun in the last few years.

Legislation on irrigation water charges has been passed, but has not yet been effectively implemented. There is generally no charge by RID for irrigation water from surface water supplies or for water from large-scale pumping projects. Provision was made under the Royal Irrigation Act of 1942 for the collection of fees from water users, but these powers were not enforced. On some of the small-scale RID pumping projects, farmers are charged for part of the energy costs.

Privately Managed Irrigation

Traditional water user organizations have managed irrigation systems in northern Thailand for hundreds of years, with no formal legal basis and no support from the Government. If the Government does provide assistance for construction of irrigation infrastructure, then the water user organization is formalized under the 1939 People's Irrigation Act. These traditional and formalized water user organizations administer farmer-owned projects under the control of village irrigation committees, and are responsible for operation and maintenance, including repair of weirs after floods and desilting of canals. No government assistance is given for operation and maintenance expenses. Water is distributed on a continual basis and proportionally allocated. In the case of shortages during the dry season, the officers of the water user organizations define priorities for water allocation with the objective of minimizing crop damage.

There is also some private development of groundwater for irrigating small-scale, market gardens growing high-value crops. Generally, there is no regulation of private pumping of groundwater. The Groundwater Act of 1977, however, requires a permit to utilize groundwater from government-designated Groundwater Areas where over-pumping is causing land subsidence. This Act is being implemented in

Bangkok and adjacent areas where there is overexploitation of the groundwater.

The National Energy Administration (NEA) has been developing small-scale, low-lift pumping projects. These small-scale irrigation projects are managed by the farmers themselves. The NEA charges farmers for the cost of energy used for the pumping.

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Thailand Development Research Institute (1987). *Thailand Natural Resources Profile.* Anat Arbhabhirama and others, editors. Bangkok.

Authors: Jac C. Heckelman and Gary Vocke

Demographics

Population	57.6 million (1992)
Population growth rate	1.4% per year (1992)
Population density	113 per square km (1992)
Urban population	23% of total population (1990)
Urban growth rate	4.6% per year (1980-90)

Economics

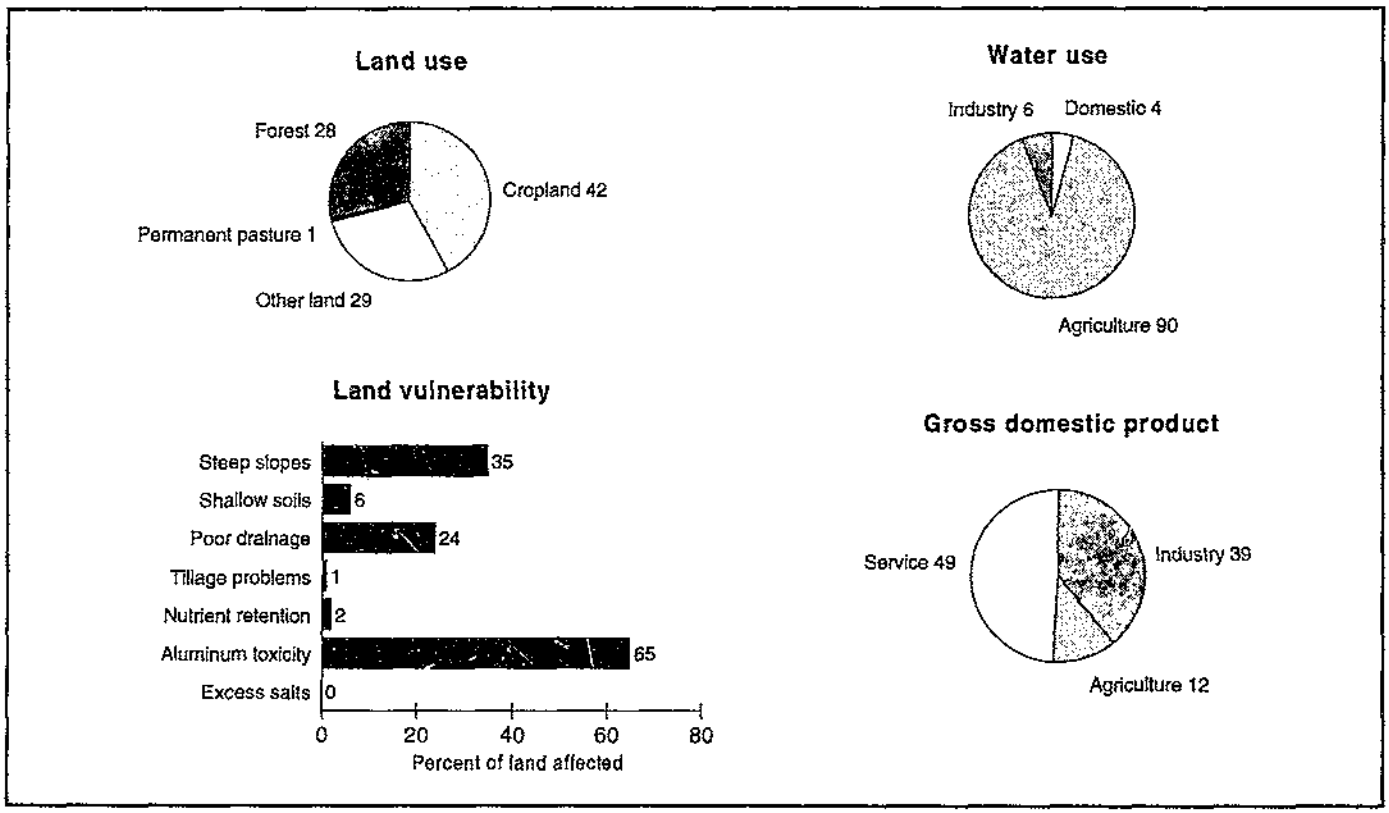
Gross domestic product	$80,170 million (1990)
GDP growth rate	7.6% per year (1980-90)
GDP per capita	$1,437 (1990)
Total external debt	32.6% of GNP (1990)

Environment

Land area	511,770 square km
Irrigated land	19% of cropland (1987-89)
Average fertilizer use	33 kg/ha cropland (1987-89)
Average pesticide use	22,289 metric tons active ingredient (1982-84)
Livestock contribution to methane	480,000 metric tons (1989)
Wet rice contribution to methane	5,700,000 metric tons (1989)
Greenhouse gas emissions	357 million tons CO_2 equivalent
Greenhouse gas emissions per capita	6.5 tons CO_2 equivalent
Land protected	10.0% of total land (1990)
Number of known threatened animal species	82 (1990)

Climate: tropical; rainy, warm, cloudy southwest monsoon (mid-May to September); dry, cool, northeast monsoon (November to mid-March); southern isthmus always hot and humid.

Environmental problems: air and water pollution; land subsidence in Bangkok area; deforestation; wildlife destruction; water scarcity; mangrove destruction and overfishing; urban environmental quality.



Turkey

A key development objective in Turkey is to reduce interregional economic differences within the country. The development of irrigated agriculture is one means to achieve this objective. Presently, a major part of this strategy is the development of waterworks on the Euphrates and Tigris rivers to promote development in the poorest region of the country. This development will have regional consequences because it will reduce the flow of water to Syria and Iraq. Both countries need this water for irrigation and Syria needs the flow for power generation.

Water Resources Ownership

In Turkey, all groundwater and surface waters except some privately owned small springs are vested in the Government by the 1982 Constitution. A permit is needed to extract groundwater. These permits are issued by the General Directorate of State Hydraulic Works (DSI) of the Ministry of Energy and Natural Resources and specify the quantity of water that can be pumped and the intended use of the water. These water-use rights can neither be sold nor transferred.

The situation for surface waters is different. Under Islamic customary rules of priority of appropriation, the user who has established a water entitlement first has precedence over all subsequent users. If any conflict arises among users concerning surface water use rights, the case is settled by the courts.

Public Irrigation Schemes

Turkey has both publicly and privately developed irrigation. Two government agencies are responsible for publicly developed irrigation. DSI is responsible for constructing the basic irrigation infrastructure for large-scale projects, and controls the release of water to the canals. The systems are supposed to operate on demand, but in practice supplies are typically scarce, giving advantages to upstream irrigators.

The General Directorate of Rural Services (GDRS) of the Ministry of Agriculture, Forestry and Rural Affairs is responsible for the construction of onfarm works on large-scale irrigation projects and for the entire development of small-scale projects. The GDRS can carry out land consolidation to ensure an efficient layout of the irrigation system. GDRS maintains the off-farm waterworks that it constructs in the small-scale schemes, but can organize the farmers into user organizations to maintain the onfarm facilities in both large- and small-scale schemes. These organizations are mainly village-based groups with the village head acting as chair. There is no legislation governing how the user associations are to be formed, nor do they have a legal status to borrow money for waterworks.

Charges for publicly supplied irrigation water, by law, are to reflect the cost of operating and maintaining irrigation facilities, plus an amount required for the recovery of capital costs, amortized over a period not exceeding 50 years. No interest is charged. The charges are assessed based on the area irrigated, with adjustments for differences in the water requirements for each crop. In practice, the amount collected has been less than charged.

Water Quality Protection

The Water Pollution Control Regulation of 1988 has restrictions on the use of wastewater, pesticides, and fertilizers in irrigated areas. The quality of wastewater used for irrigation is regulated. A permitting system is used to regulate discharges from irrigation drainage canals into water bodies. The discharge from the canals must meet specific water quality standards. Land-use zoning restricts activities near the sources of drinking water.

Regional Development Project

Southeastern Anatolia Project is a regional development project encompassing nearly 10 percent of the area of the country. The development includes several major irrigation and power projects on the Euphrates and Tigris rivers. When the waterworks are completed, the area in the country irrigated by state-supplied water will be doubled. Besides the waterworks for irrigation and power, this effort also involves rural and urban development activities.

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International Action Programme on Water and Sustainable Agricultural Development (1993). *National Action Programme. Republic of Turkey.* Food and Agriculture Organization of the United Nations. Rome.

Author: Gary Vocke

Demographics

Population	59.6 million (1992)
Population growth rate	2.1% per year (1992)
Population density	77 per square km (1992)
Urban population	61% of total population (1990)
Urban growth rate	5.9% per year (1980-90)

Economics

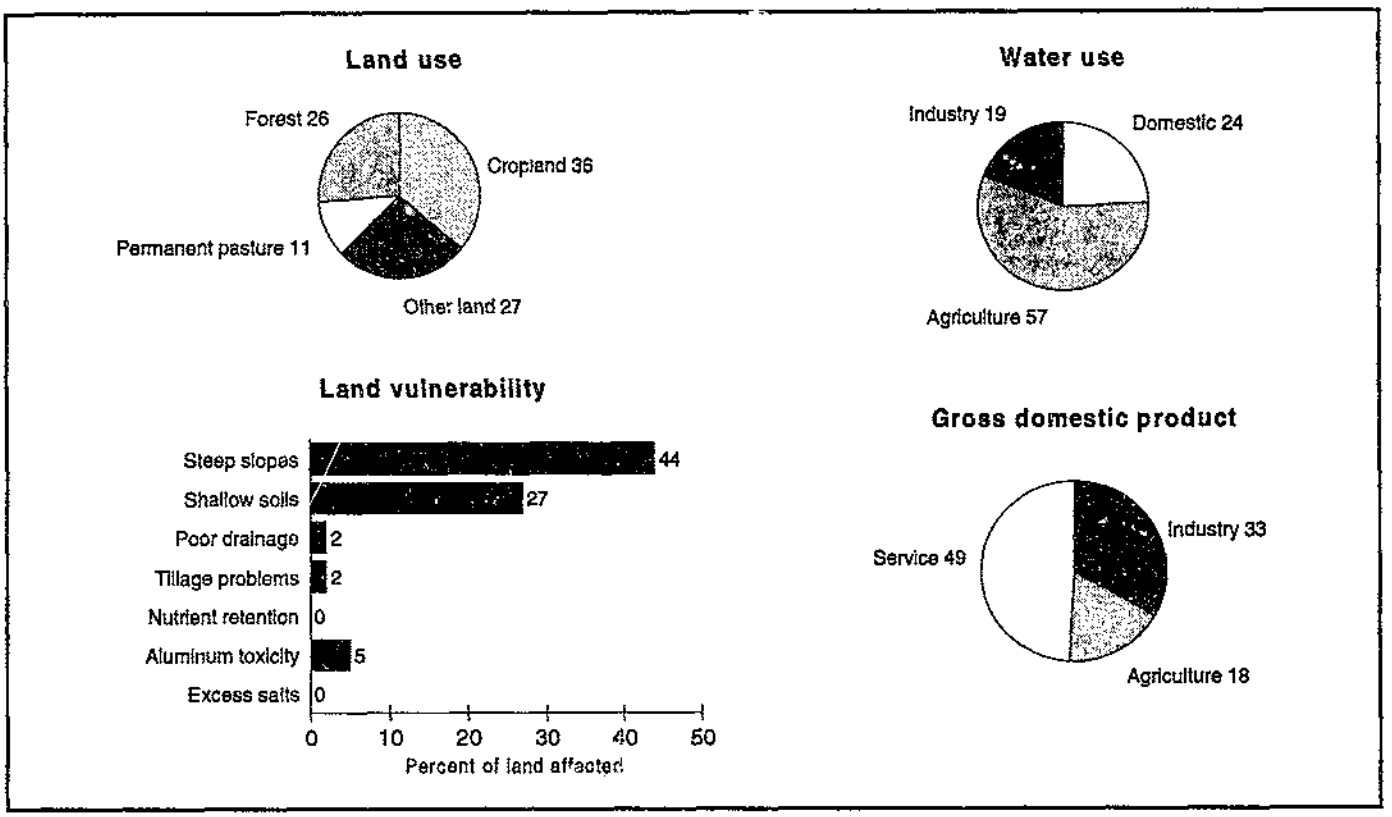
Gross domestic product	$96,500 million (1990)
GDP growth rate	5.1% per year (1980-90)
GDP per capita	$1,720 (1990)
Total external debt	46.1% of GNP (1990)

Environment

Land area	770,760 square km
Irrigated land	8% of cropland (1987-89)
Average fertilizer use	62 kg/ha cropland (1987-89)
Average pesticide use	9,000 metric tons active ingredient (1982-84)
Livestock contribution to methane	700,000 metric tons (1989)
Wet rice contribution to methane	33,000 metric tons (1989)
Greenhouse gas emissions	130 million tons CO_2 equivalent
Greenhouse gas emissions per capita	2.4 tons CO_2 equivalent
Land protected	0.3% of total land (1990)
Number of known threatened animal species	34 (1990)

Climate: temperate; hot, dry summers with mild, wet winters; harsher in interior.

Environmental problems: subject to severe earthquakes, especially along major river valleys in west; air pollution; desertification; water pollution; deforestation.



United Kingdom

The administrative structures in the States of the United Kingdom differ, but the basic theme is the same: management by major river basin. The administrative boundaries of the authorities are determined by the watersheds of natural river basins and not by political boundaries. Water management has evolved through a series of Water Acts.

Water Legislation in England and Wales

The Water Resources Act of 1963 moved States toward comprehensive river basin management and curtailed the surface and groundwater rights of riparian owners. This Act extended the responsibility of river authorities from pollution control and drainage functions to include planning and controlling the use of water resources. The water authorities introduced a licensing system for withdrawals from rivers and aquifers. The goal of the system was to reduce riparian wastefulness by licensing only beneficial uses of water. A license is not needed, however, if the abstraction is less than 1,000 gallons per year, if the abstraction is by a riparian owner for domestic or agricultural use (not including spray irrigation), or if the abstraction is from a groundwater source for domestic use.

A potential water user cannot make an application for a license unless the user occupies land next to the surface water body or above the underground water supply. An application for a license must be refused if the proposed extraction would limit the already licensed extraction of existing water users.

The 1973 Water Act completed the move toward comprehensive river basin management. The Act gave water authorities responsibility for supplying drinking water and for sewage disposal services. The boundaries of the river authorities were reorganized to follow river catchment areas rather than administrative areas.

The Water Act of 1989 privatized the water authorities. The water supply and sewerage functions of the 10 water authorities were privatized into 10 utility companies with shares traded on the Stock Exchange. Because these 10 utility companies became private monopolies of a service on which people depend, an Office of Water Services was created to monitor and regulate these companies' charges and quality of service and to provide consumer representation. This Office of Water Services reports directly to Parliament.

The 1989 legislation also created a National Rivers Authority (NRA). The NRA's responsibility is to regulate discharges into water and enforce environmental water laws. The pollution control function could not be privatized because a European Union (EU) Directive requires that authorizations for discharging dangerous substances are to granted by a "competent authority." A private company answerable to its shareholders does not meet this requirement.

Scotland and Northern Ireland have management by river basin, but there is no privatization of the delivery of services.

Agriculture and the EU Water Quality Directives

In some areas, the nitrate level exceeds the EU standard of 50 mg/liter. Livestock wastes are the major source of this nitrate. There is some leaching of nitrates in the intensively cropped lowland areas. There are also some problems with silage effluent polluting water supplies.

The Department of the Environment (DOE), which has general responsibility for environmental quality, has been able to introduce a series of regulatory measures to deal with water pollution from municipal and industrial sources. However, the Ministry of Agriculture, Fisheries and Food (MAFF) has been able to maintain control of environmental policy for agriculture. Although the 1974 Control of Pollution Act made it an offense to pollute surface water by manure, silage effluent, and dirty feedlot water, the MAFF has generally favored using advice and encouragement rather than regulations for dealing with farm-related pollution. In designated, Environmentally Sensitive Areas (ESA's), payments are made to farmers who voluntarily adopt "environmentally friendly," less intensive farming practices.

In 1980, the EU enacted its 50 mg/liter (nitrate level) drinking water standard. The UK Government enforced the standard through water treatment measures. Where possible, contaminated sources were blended with higher quality sources before the water was delivered to users. Where high-quality sources were not available, denitrification technology was employed.

The 1989 Water Act has provisions for preventing agricultural sources of nitrate pollution, including

Nitrate Sensitive Areas (NSA's) in which farming practices could be regulated to reduce nitrate pollution of water supplies. The MAFF was given responsibility for implementing the NSA's scheme. MAFF introduced the policy on an experimental basis in 10 small farming areas in 1990. MAFF's approach was based on guidelines set out in a Code of Good Agricultural Practice for the Protection of Water in the 1989 Water Act. The NSA's were operated on a voluntary basis, with farmers receiving payments for introducing changes to agricultural practices and land use. Farmers within the NSA's may join a Basic Scheme, which places limitations on the use of nitrogen fertilizers and the plowing of grassland. Or farmers may enter a Premium Scheme, which requires cropland to be converted to alternative uses. Compensation is greater under the Premium Scheme.

As of 1993, the farmers in NSA's had to comply with the Code of Good Agricultural Practice for the Protection of Water. Complying with the Code is still voluntary outside NSA's.

Although the NRA is responsible for regulating the discharge of polluting material, these authorities have not regarded the recycling of livestock wastes to the land as the discharge of polluting material. Failure to comply with the Code of Good Agricultural Practice for the Protection of Water is not necessarily an offense, but if pollution occurs, the NRA can compare the farmer's practice with the Code in deciding whether to prosecute and may bring it to the attention of the courts. The NRA has regulations enforcing good practices for storage of manure slurry, silage, and agricultural fuel oil. Failure to comply with these regulations for newly constructed and substantially reconstructed or enlarged facilities, irrespective of whether pollution is actually occurring, will be an offense. The 1989 Farm and Conservation Grant Scheme provides grants for constructing, replacing, or improving these storage facilities.

The policy situation changed in 1991 when EU directives extended nitrate protection to all waters, whether they are for human consumption or not. The country was given 4 years to restrict the use of nitrogen fertilizer in vulnerable zones. Vulnerable zones are defined by EU directive as areas where water is likely to contain more than 50 mg nitrate/liter if preventative action is not taken. The NRA is making plans to designate groundwater protection zones in which measures will be developed to restrict agricultural activities that may contaminate groundwater within these zones.

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Authors: Jac C. Heckelman and Gary Vocke

Demographics

Population	57.8 million (1992)
Population growth rate	0.3% per year (1992)
Population density	239 per square km (1992)
Urban population	89% of total population (1990)
Urban growth rate	0.2% per year (1980-90)

Economics

Gross domestic product	$975,150 million (1990)
GDP growth rate	3.1% per year (1980-90)
GDP per capita	$16,989 (1990)

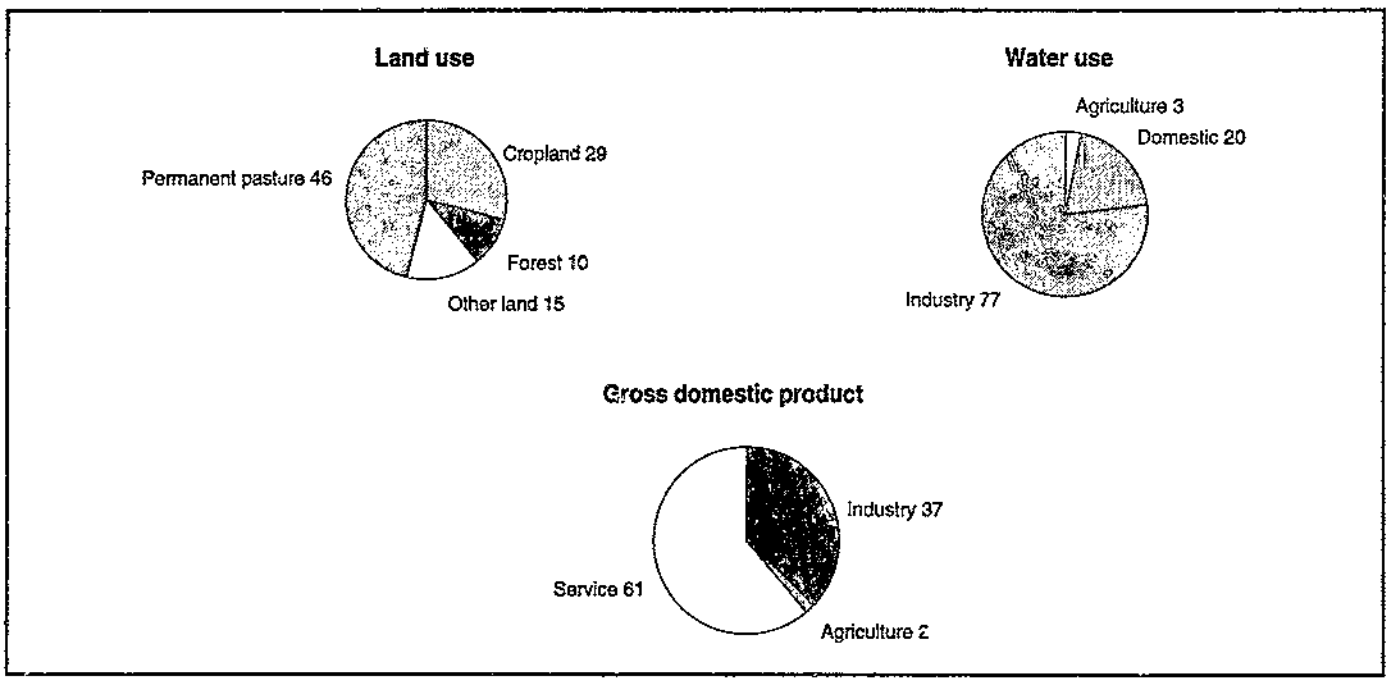
Environment

Land area	241,590 square km
Irrigated land	2% of cropland (1987-89)
Average fertilizer use	359 kg/ha cropland (1987-89)
Average pesticide use	34,147 metric tons active ingredient (1982-84)
Livestock contribution to methane	900,000 metric tons (1989)
Wet rice contribution to methane	NA
Greenhouse gas emissions	726 million tons CO_2 equivalent
Greenhouse gas emissions per capita	12.7 tons CO_2 equivalent
Land protected	18.9% of total land (1990)
Number of known threatened animal species	25 (1990)

Climate: temperate; moderated by prevailing southwest winds over the North Atlantic Current; more than half the days are overcast.

Environmental problems: pollution control measures are improving air and water quality; because of heavily indented coastline, no location is more than 125 km from tidal waters; radon.

NA = Not available/applicable.



United States

The responsibility for developing, managing, and protecting the country's water resources is shared among the Federal Government, State government and local institutions, and private individuals. This discussion focuses on three aspects of these responsibilities: (1) the role of the States to manage water supply; (2) the Federal development of water for irrigation in the arid and semiarid West; and (3) the Federal role in protecting water quality.

States Manage Water Supplies

Each State government can develop its own legal system governing the use of water. The States initially followed one of two legal systems for surface waters: riparian or prior appropriation. No two States have exactly the same legal system. The States have generally developed legal systems for groundwater that are different from those for surface waters. In the case of interstate waters, water can be allocated between States through lawsuits in the U.S. Supreme Court, agreements between the States, apportionment by the U.S. Congress, or Federal administrative license.

Riparian System for Surface Water

In the humid, eastern half of the country and along the west coast where water is also abundant, the riparian system was adopted. In most States following this system, landowners bordering a watercourse have a right to a reasonable use of the water and to be safe from harm by others making unreasonable use of the water. The right of use arises out of land ownership, but the landowner does not own the water in the stream. Courts determine whether or not a use is reasonable after a dispute is brought. This determination of reasonableness is subject to re-evaluation when circumstances change. Thus, a riparian landowner's right to the use of water is not a right to a fixed quantity, but rather, is dependent upon the extent of development that has taken place along the water body. About two-fifths of the States are under some variation of this legal system.

The system of riparian rights is a way of allocating water when there is an ample supply. However, rising urban and industrial demands have forced about 10 percent of the riparian States to switch to regulatory permitting systems. With a regulatory permitting system, administrative officials choose among competing users and can ensure minimum water flows for fish and other public purposes.

Prior Appropriation System for Surface Water

The Western United States was faced with deciding how to allocate scarce water resources for uses such as irrigating land that does not border the watercourse. These Western States developed a system called prior appropriation, where a right to a fixed amount of unappropriated water can be obtained if the water is diverted and put to beneficial use regardless of where the use is located. The right to use does not arise by land ownership, but by putting the water to a beneficial use. The earliest water right on a given watercourse has preference over later users. Thus, this priority of earlier rights becomes the basis for dividing water among water users during periods of scarcity. More than 10 percent of the States follow some variation of this legal system, and an equal number use a combination of appropriative and riparian rights.

The prior appropriation system provides for a more secure right to water than the riparian system, especially for the early appropriators. This security is important if large waterworks investments like irrigation infrastructure are to be made. Generally, States allow the holder of an appropriative water right to make changes in the point of diversion or the place or purpose of use without loss of priority so long as there is no impairment of other water rights. If the appropriator fails to make use of the water for a relatively short period of time, the water right will be given to someone else.

Some Western States have been modifying their surface water legal systems and the criteria for allocation of unappropriated water to include protection of instream uses beyond hydropower and navigation. These additional uses include wildlife habitat, wild rivers, and recreation.

Water Allocation Systems for Groundwater

Four basic groundwater systems are employed by the States: absolute ownership, reasonable use, correlative rights, and prior appropriation. Under absolute ownership, overlying landowners can withdraw any quantity of water from beneath their land for any use without liability for harm to their neighbors. About 20 States follow this system.

Almost as many States follow the reasonable use system. Reasonable use recognizes the rights of adjacent landowners to a limited extent; the extracted water must be for a reasonable use. This doctrine

ensures that the groundwater is used for a productive purpose. But the reasonable use system does not ensure that the available water is equally shared among overlying landowners. For a reasonable use, the overlying landowner may use groundwater to the extent of limiting the supply of groundwater to neighboring lands. A single landowner's extraction may even exceed the safe-yield of the groundwater source, provided the purpose is held to be reasonable, as decided by the courts. Groundwater may be extracted by an overlying landowner for sale or use on other land only if this extraction can be done without injury to adjoining landowners or to prior appropriators.

Under the correlative rights system, the landowner's use must not deprive adjoining landowners of their fair share of the groundwater, even for a reasonable use. This system permits an overlying landowner to petition the court to decide the water rights of all users. The court establishes, from hydrogeological evidence, the area of the groundwater basin in question, its safe-yield, and any existing drawdown caused by overpumping. The court then prorates allowable extractions among overlying landowners. In determining the water rights of each user, the court may allocate rights that do not exceed safe-yield, and may also determine the proportions in which existing uses have to abate in order to make up any existing drawdown. In a time of water shortage, each landowner is entitled to a share of the underlying water in the same proportion as their area of land to the area supplied from the common groundwater source. Thus, the courts have a larger task under this system than under reasonable use. Where there is water surplus to the needs of overlying landowners, it may be appropriated by nonoverlying users. Only California follows the correlative rights system.

The remaining States follow the prior appropriation system. Prior appropriation allows withdrawal of groundwater for a beneficial use after obtaining government approval. The administrative official must determine if unappropriated groundwater exists and evaluate any adverse effects before approving the application to extract water. Sometimes, State water officials have the power to designate certain areas as a critical water basin and place the users under their direct control for the protection of the aquifer (water-bearing permeable rock, sand, or gravel) and vested rights.

Irrigation Development in the West

The Federal Government began its involvement in Western water development under its general policy to promote settlement of the West. The Reclamation Act of 1902 created the Bureau of Reclamation and charged it with planning and constructing major irrigation projects in the West. The 1902 Act states that the title and operation of the reservoirs will remain with the Federal Government, while the offstream irrigation works are the responsibility of the irrigators. The Bureau acquires the right to use the water from the State, then contracts for delivery of a certain quantity of water to a water organization, usually a water district, which allocates it to the irrigators. The policy of the Federal Government has been to provide water to farmers at less than the full cost of delivering it to the irrigators.

Of the total Western irrigated area, about 20 percent was developed by the Bureau. The remainder of the irrigated area was primarily developed by the private sector.

By midcentury, breakthroughs in pumping technology and in center-pivot irrigation systems allowed irrigation of land too rolling for gravity irrigation. This technology, and declining availability of easily developed surface water, led to rapid private-sector irrigation development in the Plains States. Pumping increased so much that many regions now have declining groundwater levels. In some of these areas, States are requiring meters to be installed on each well to monitor the pumping and to enforce pumping limits.

Water Organizations

Three basic forms of water organizations deliver water to irrigation schemes: not-for-profit companies that deliver water just to their shareholders, commercial companies that deliver water to nonshareholder irrigators for a profit, and irrigation districts created by the States. Commercial companies have a very small role in supplying water for irrigation. The not-for-profit companies and the irrigation districts are vertically integrated organizations combining both water suppliers and water users. These two types of organizations are about equally important in terms of area irrigated.

The not-for-profit water companies' customers are also their shareholders. Each share entitles the owner to a portion of the water. Shareholders can be assessed for their proportion of operating and capital costs.

States can create water districts for local water management, including irrigation. States can give the districts the power to manage the allocation of water

including, sometimes, transfers to promote efficient use of project water. Districts are legal entities favored in several ways so they can obtain funds for constructing waterworks. They can assess levies, issue bonds that are exempt from Federal income taxes, and raise revenue through water charges. Besides irrigation water, districts can also deliver water for nonagricultural uses.

District board members are usually elected, but districts vary in their procedures for selecting board members. The right to vote for board members may, for example, be with each voter in the district, or with each landowner, or may be weighted according to landholding.

Irrigation Development Slows Down

Irrigation development is slowing, if not stopped, as the West makes the transition from water development to water management and conservation. For example, the Reclamation Reform of 1982 promotes irrigation water conservation by requiring irrigation districts to develop water conservation plans and to adopt economically feasible water conservation measures. Bureau of Reclamation project construction peaked in the mid-1960's.

The West's nonagricultural water demands are rising. To facilitate the expansion of water markets to reallocate irrigation water to nonagricultural uses in California, 1992 Federal legislation now allows irrigators receiving subsidized water from the Bureau of Reclamation in the Central Valley Project to directly transfer water to uses outside of the project. This legislation also provides that some water previously diverted for irrigation is to remain in the streams for fish.

Federal Protection of Water Quality

Until the mid-1960's, the States were almost exclusively responsible for water pollution control. Declining surface water quality, however, led the Federal Government into a supervisory role. Federal legislation to protect water quality has focused on surface waters. States have retained the primary role in protecting groundwater aquifers.

In the Water Quality Act of 1965, national legislation required the States to establish water quality standards for interstate surface waters and a plan to achieve these water quality standards. This legislation, however, did not provide the Federal Government with a mechanism to enforce these requirements.

The National Environmental Policy Act of 1969 created the Environmental Protection Agency (EPA) by combining existing programs throughout the Federal Government. The EPA was given the responsibility to set and enforce Federal water-quality standards in the States. States could still develop their own plans and then request EPA to grant them the authority to implement their plan.

Congress changed the focus of Federal efforts when it rewrote the Water Quality Act in 1972, and later amended it in 1977. The approach shifted from water-quality standards to technology-based standards. This new framework required equal limits on all similar point sources of water pollution, and mandated that any discharge be authorized by a National Pollutant Discharge Elimination System (NPDES) permit. A NPDES permit is required for feedlots with over 1,000 animal units or for any feedlot with over 300 animal units that directly discharges into navigable waters. States have the power to establish lower limits for requiring permits. Before the permit is issued, appropriate pollution control facilities must be constructed. The Water Quality Act, as amended in 1977, is commonly called the Clean Water Act (CWA). States can petition EPA for the authority to implement the permitting plan.

Other sources of water pollution were also not covered by the CWA. Agricultural runoff from croplands, for example, escapes direct CWA regulation because it is defined as a nonpoint source. The 1977 CWA allowed States almost unlimited discretion over the control of nonpoint sources of pollution.

In 1986, an amendment to the Federal 1974 Safe Drinking Water Act required States to submit programs to protect wellhead areas from contaminants, including pesticides and nutrients. Upon approval of a State program, Federal funding is authorized to cover part of the costs incurred by the State in developing and implementing its program.

In 1987, the CWA was amended to create the Nonpoint Source (NPS) Management Program. Under the NPS Management Program, States are to identify navigable waters requiring reduction of nonpoint source pollution and to develop plans to control nonpoint pollution through Best Management Practices (BMP's). State plans can make use of voluntary or mandatory measures for implementing BMP's. The EPA, however, was not given the authority to develop a NPS Management Program when a State fails to prepare an adequate plan. The

legislation does provide for some grants to the States to implement the plans. All States now have EPA-approved plans.

The management of nonpoint sources of pollution in coastal areas is slightly different. Under the Coastal Zone Act Reauthorization Amendments of 1990, States with federally approved coastal zone management programs are to develop coastal nonpoint pollution control plans by 1995. These State plans are to initially employ technology-based standards, to be followed by more stringent water quality-based standards where necessary to address known water quality problems. The EPA has specified the management measures that can be included in the plans. States must require their farmers to use the BMP's in the State plans. However, the EPA does not have the authority to force a State to develop a coastal zone management program.

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) of 1988 provides the EPA authority to regulate the sale and use of pesticides through a registration program. In addition to the power to deny registration, FIFRA provides EPA with the authority to regulate the methods of use and application of registered pesticides.

Finally, the Department of Agriculture also provides programs for education and financial and technical assistance to farmers, ranchers, local organizations, and multicounty areas to implement water conservation and water quality improvement.

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Author: Gary Vocke

Demographics

Population	254.5 million (1992)
Population growth rate	0.8% per year (1992)
Population density	28 per square km (1992)
Urban population	75% of total population (1990)
Urban growth rate	1.1% per year (1980-90)

Economics

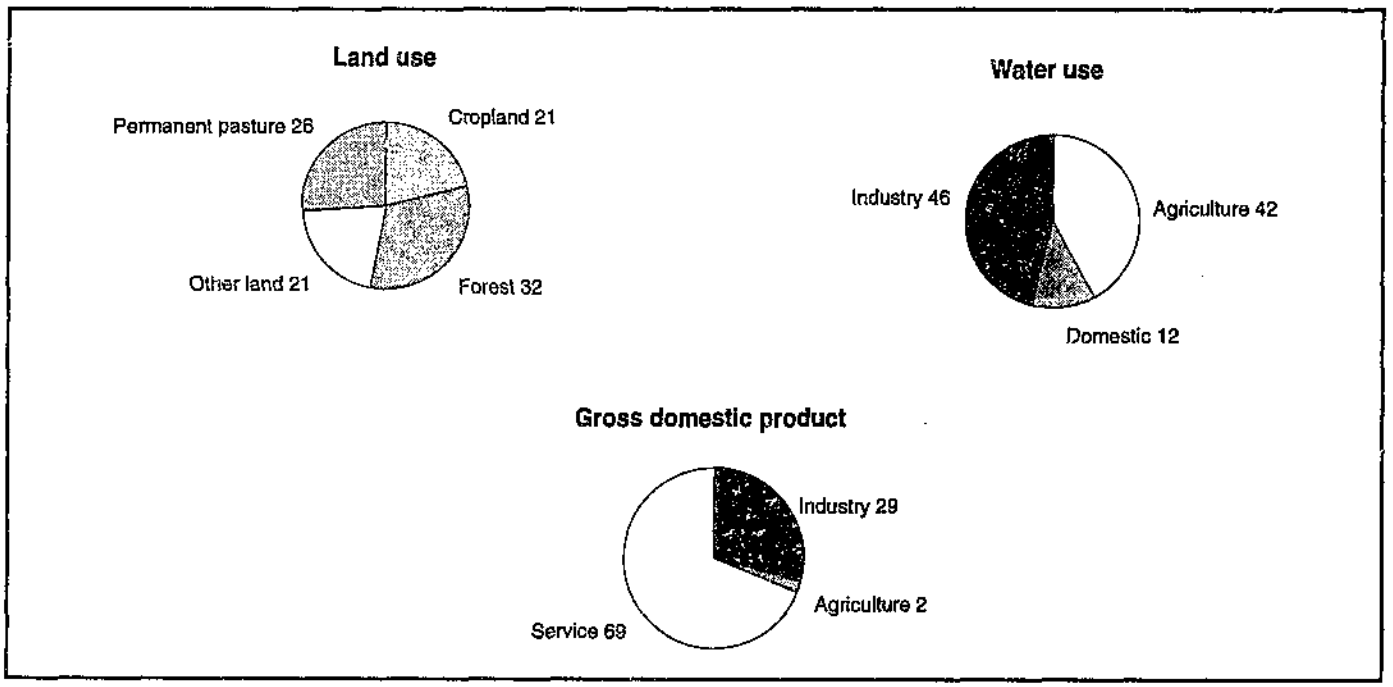
Gross domestic product	$5,392,200 million (1990)
GDP growth rate	3.4% per year (1980-90)
GDP per capita	$21,569 (1990)

Environment

Land area	9,166,600 square km
Irrigated land	10% of cropland (1987-89)
Average fertilizer use	95 kg/ha cropland (1987-89)
Average pesticide use	373,333 metric tons active ingredient (1982-84)
Livestock contribution to methane	6,000,000 metric tons (1989)
Wet rice contribution to methane	740,000 metric tons (1989)
Greenhouse gas emissions	5,163 million tons CO_2 equivalent
Greenhouse gas emissions per capita	21.0 tons CO_2 equivalent
Land protected	10.5% of total land (1990)
Number of known threatened animal species	275 (1990)

Climate: mostly temperate, but varies from tropical (Hawaii) to arctic (Alaska); arid to semiarid in West with occasional warm, dry chinook wind.

Environmental problems: pollution control measures are improving air and water quality; acid rain; agricultural fertilizer and pesticide pollution; management of sparse natural water resources in West; desertification; tsunamis, volcanoes, and earthquakes around Pacific Basin; continuous permafrost in northern Alaska is a major impediment to development; global warming contribution.



Zambia

The Department of Water Affairs is responsible for the development and maintenance of drinking water supplies and delivery systems in small and medium-sized townships. The Department also develops rural water supplies, which primarily involves the drilling of wells. Local governments are expected to take over operation and maintenance of these schemes, but this transfer of responsibility has been slow to develop. City councils are responsible for the provision of drinking water and sewage disposal in the 10 largest municipalities.

Several major rivers and lakes border or pass through Zambia. The most economically important water body is the Kafue River, which services all the major urban areas.

Water Rights

Water rights in Zambia vary according to whether the user is primarily subject to traditional laws and on the type of water. Formal laws distinguish between public and private water on the basis of whether the water would naturally flow off the holding of the user. For example, private water includes swamps fully contained on a single parcel, a spring that is fully contained on and does not flow from a single parcel, and water from a well.

Use of private water is generally not controlled by the Government. Any diversion of public water requires a permit from the Water Development Board, but most Zambians feel they have a traditional right to use water on or adjacent to their land. Industrial users typically follow the legal tenets. After payment of a fee, an applicant advertises the proposed water use in the government gazette and in a public newspaper. In areas where users are primarily subject to traditional laws, the consent of the local chief is also required. Then a Water Officer or a qualified engineer investigates the proposed use. If problems are not encountered, the water right is granted. Such rights, however, are often conditional on use of erosion controls, maintenance of the water structure, compliance with easements, and other constraints. Partial rights are also assigned for abutment (to anchor a dam on the border of another's land), storage (by way of flooding), and passage (to move water across another's land).

Water rights are registered, usually for a maximum of 5 years, for uses outside a township, but the rights may be renewed for an additional 5 years. The short life of these rights is in recognition of the poor information on water flow and use.

Limited Irrigation

Irrigation is not widely used in Zambia. The Fourth National Development Plan (1989) includes the objective of increasing land under irrigation, but most rights in the Kafue river system are already allocated to the Zambia Electricity Supply Company for hydroelectric power production. These rights are constrained by minimum flow requirements designed to protect dry-season grazing areas, but they conflict with potential irrigation demands.

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Author: Carl Mabbs-Zeno

Demographics

Population	8.7 million (1992)
Population growth rate	3.5% per year (1992)
Population density	12 per square km (1992)
Urban population	50% of total population (1990)
Urban growth rate	6.2% per year (1980-90)

Economics

Gross domestic product	$3,120 million (1990)
GDP growth rate	0.8% per year (1980-90)
GDP per capita	$385 (1990)
Total external debt	261.3% of GNP (1990)

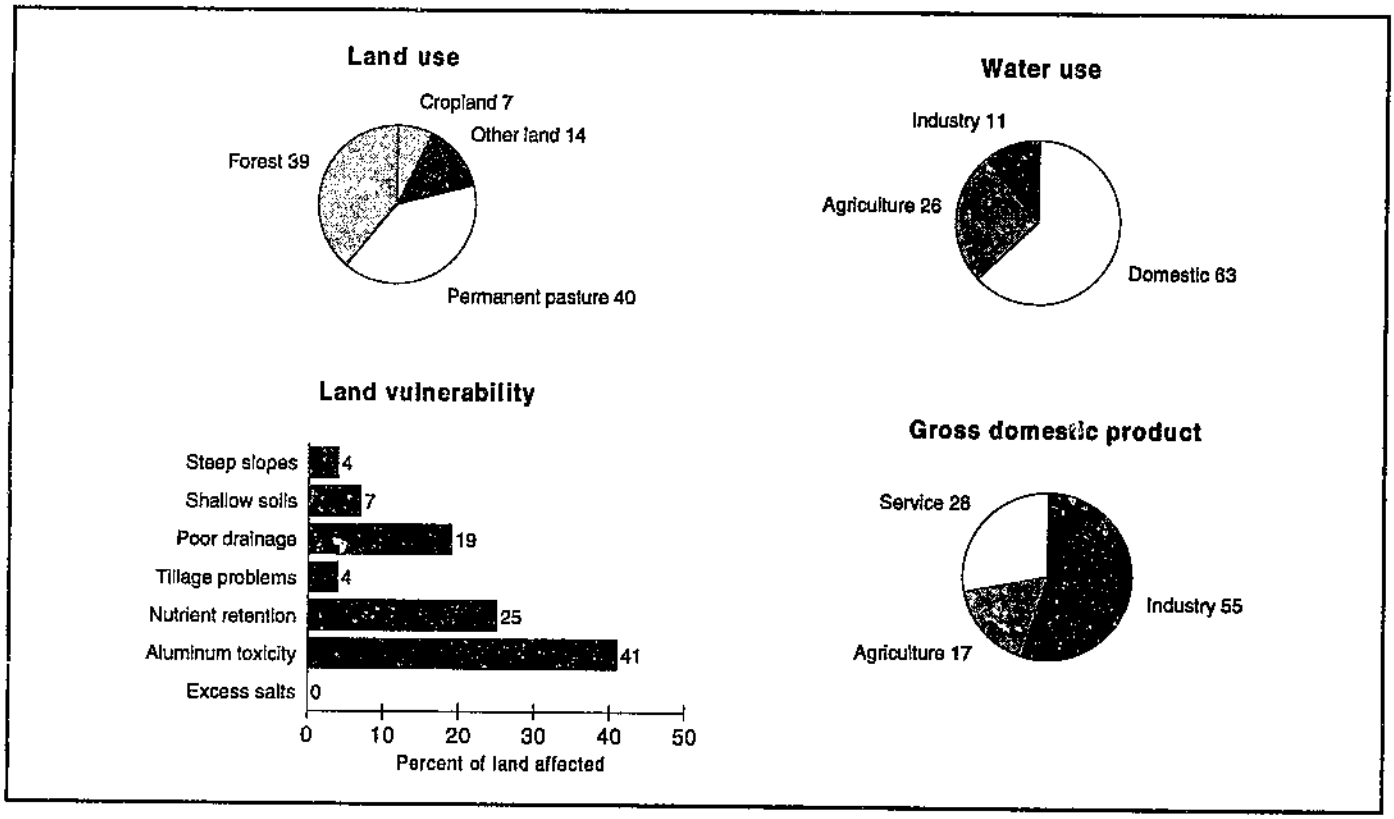
Environment

Land area	740,720 square km
Irrigated land	1% of cropland (1987-89)
Average fertilizer use	17 kg/ha cropland (1987-89)
Average pesticide use	NA
Livestock contribution to methane	100,000 metric tons (1989)
Wet rice contribution to methane	6,000 metric tons (1989)
Greenhouse gas emissions	25 million tons CO_2 equivalent
Greenhouse gas emissions per capita	3.3 tons CO_2 equivalent
Land protected	8.5% of total land (1990)
Number of known threatened animal species	22 (1990)

Climate: tropical; modified by altitude; rainy season (October - April).

Environmental problems: deforestation; soil erosion; desertification; wildlife conservation.

NA = Not available/applicable.



European Union

Most water consumption in the European Union (EU) is for urban and industrial uses, not agricultural. Even though agriculture is not a major consumer, it still has a prominent role in water management because of its impact on water quality. The intensification of crop and livestock production has led to contaminated surface waters and groundwater in certain areas of Europe.

Agricultural Pollution of Water Resources

Livestock manure and manufactured fertilizers are considered to be the primary sources of the rising nitrogen levels in surface waters and groundwater. Modern, confinement livestock production allows for heavy regional concentrations of livestock and, hence, production of manure. In some regions, the production of manure exceeds the land's nitrogen recycling capacity, with the excess nitrogen entering the water supplies. Compounding the excess manure problem is the heavy application of manufactured fertilizers.

EU Water Quality Legislation

The EU passes framework directives that establish broad principles for member countries. Each country then applies these principles to its own situation. Some of the more important environmental legislation affecting agriculture is reviewed here.

The EU provides financial assistance to member countries to implement these environmental measures. Generally, the EU will first determine the maximum level to which it will subsidize a farmer to carry out a particular activity to protect the environment. The individual countries then determine how many ECU's (European Currency Units)/hectare they will provide to each farmer to carry out that activity. The EU will then match the country contribution up to the EU limit.

Environmentally Sensitive Areas

EU legislation in 1985 enabled member countries to establish a voluntary system of national aid for environmentally sensitive areas (ESA's). Individual countries can designate ESA's where farmers will be given financial assistance to voluntarily pursue environmentally friendly practices. These practices include stopping farming entirely, reducing fertilization and pesticide treatment of crops, reducing livestock density, and restricting mowing and plowing.

Extensification

An EU measure known as extensification was approved in 1988. Extensification seeks to reduce fertilizer and pesticide use and promote less intensive livestock raising. Input use is supposed to be cut enough to reduce agricultural production by 20 percent in 5 years. Member countries are responsible for determining the conditions for the granting of aid to producers to carry out this scheme. This scheme is to operate with a set-aside scheme under which farmers take 20 percent of their cropland out of production for 5 years in return for annual payments.

Nitrate Directives

In the 1980's, the EU introduced its 50 mg nitrate/liter Drinking Water Standard. This EU standard is the maximum admissible limit for nitrates in drinking water, not a guideline or average figure.

In 1991, a new directive extended nitrate protection to all waters, whether they are for human consumption or not. The directive gave the member countries 4 years to begin restricting the use of nitrogen fertilizer in vulnerable zones. Vulnerable zones are defined by the EU as areas where water is likely to contain more than 50 mg nitrate/liter if preventative action is not taken. The restrictions will involve the application of a Code of Good Agricultural Practice. Once the directive is fully implemented, the application of animal manure on the land will generally be limited to 170 kg nitrogen/hectare. This directive may also place limits on the use of fertilizers.

Afforestation

In 1991, EU legislation was passed enabling member countries to grant aid for the afforestation of agricultural land. The EU itself will help fund the grant for a maximum of 20 years from the initial afforestation.

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International Freshwater Agreements

There are 214 rivers in the world that are shared by countries: 148 flow through 2 countries; 31 through 3; and 62 through 4 or more nations (Rogers, 1991). The river basins of these shared rivers account for more than 50 percent of the land area of the world, and some of the most productive agricultural land. To manage these international resources, around 300 treaties have been signed, two-thirds of these in Europe and North America. These treaties primarily address navigation, apportionment, and flood control; less frequently confronted are the topics of water quality and river basin ecosystems (Linnerooth, 1990). This section will discuss the major multilateral and U.S. bilateral freshwater agreements that seek to manage water resources for environmental purposes. Some major international water systems, such as the Danube, are not discussed because the adjacent countries are not party to international water treaties governing water quality.

Legal Frameworks and Principles

Although an international legal framework for the development and use of shared rivers does not exist, four principles have emerged (Linnerooth, 1990; Rogers, 1991). The principle of absolute sovereignty implies that a country has the right to use the water flowing through its territory in any way it pleases. Upstream countries tend to prefer this doctrine. The principle that all riparian countries exercise sovereignty over the river is preferred by downstream nations, since it implies that they can receive the water in an unaltered state. The third principle is that of river basin development, in which the entire hydrological unit is considered as a whole and the use of the waters is planned accordingly. The fourth doctrine, that of equitable use, allows sovereignty over the waters within country boundaries, provided other riparian nations receive a reasonable share.

Multilateral Freshwater Agreements

There are three multilateral conventions for the protection of the Rhine, a major waterway flowing through northwestern Europe. These conventions promote an international commission and seek to control chlorides and other chemical pollutants. The Agreement Concerning the International Commission for the Protection of the Rhine against Pollution seeks to reinforce cooperation among the countries bordering the river and improve Rhine water quality. The agreement was adopted in 1965 and amended in 1976 and 1979. The contracting parties are France, Germany, Luxembourg, the Netherlands, Switzerland, and the European Economic Community. The convention provides for the continuation of the International Commission for the Protection of the Rhine and stipulates its responsibilities, namely to conduct pollution research, suggest protection measures, report annually on its research, and collaborate with other water pollution organizations.

The Convention on the Protection of the Rhine against Chemical Pollution was adopted in 1976. Its contracting parties are the same as those of the earlier convention. This agreement seeks to protect the Rhine against chemical pollution in order to improve water quality. The discharge of particular substances into the Rhine is authorized or regulated by the contracting governments. The emission standards of the regulated substances are determined by the International Commission.

The Convention Concerning the Protection of the Rhine against Pollution by Chlorides was adopted on the same date as the second agreement, although it did not enter into force until 1985. The contracting parties are the five states that signed the two other Rhine conventions. The convention seeks to control chloride pollution in the Rhine in order to improve water quality. The International Commission is to propose methods to gradually reduce the chloride ion concentration. The contracting parties agree to try to avoid an increase in the discharge of ions into the catchment area and to notify the Commission of sudden rises in the ion levels or accidents that may endanger water quality.

There are four multilateral agreements concerning river basins and lakes in Africa, although only two are currently in effect. The Convention and Statute Relating to the Development of the Chad Basin seeks to increase cooperation in the development of the Chad Basin and establishes an intergovernmental commission. The agreement was adopted in 1964, amended in 1972, and has yet to enter into force. The parties to the agreement are Cameroon, Chad, Niger, and Nigeria. The provisions of the agreement establish that all parties can use the basin, provided that no harm is done to the rights of the other parties. The parties agree that they shall refrain from any action that may cause an appreciable effect on water quantity, quality, or the flora and fauna without first consulting the other parties. The Chad Basin Commission is to act as a liaison between the contracting states in order to facilitate the efficient use of the water, and is to collect, evaluate, and

disseminate proposals and recommendations on joint programs.

The Convention Concerning the Status of the Senegal River and the Convention Establishing the Senegal River Development Organization seek to encourage cooperation among the riparian states (Mali, Mauritania, and Senegal) in the management and development of the Senegal River. The agreement was adopted in 1972, amended in 1975, 1978, and 1979, and has not yet entered into force. The parties agree to undertake agricultural or industrial projects that may appreciably alter the river only with prior approval from the other states. The Senegal River Development Organization is to develop a program for the coordinated development and wise exploitation of the water resource.

The Convention Creating the Niger River Basin Authority and Protocol Relating to the Development Fund of the Niger Basin was adopted in 1980 and entered into force 2 years later. The contracting parties are the riparian states and members of the previous Niger River Commission: Benin, Burkina Faso, Cameroon, Chad, Guinea, Cote d'Ivoire, Mali, Niger, and Nigeria. The Niger River Basin Authority is charged with the harmonization and coordination of equitable development policies, monitoring of the regional policy for the use of surface and groundwater, research, and construction and maintenance of development structures. The development fund, financed through member contributions and outside grants, will provide the financial resources to carry out the goals of the Authority.

The Agreement on the Action Plan for the Environmentally Sound Management of the Common Zambezi River System aims to coordinate the management of the Zambezi riparian area. The agreement was adopted and entered into force in 1987. The contracting parties are Botswana, Mozambique, Tanzania, Zambia, and Zimbabwe. The member states agree to adopt a specified Action Plan, provide for institutional and financial arrangements for the Plan, and establish national focal points for implementation of the Plan. The Action Plan contains four elements: national and subregional environment evaluations; environmental management; promotion of legislation and basin development; and support for research, training, and educational measures.

In Latin America, there is only one major multilateral river agreement, the Treaty for Amazonian Cooperation. The objective of the treaty is to encourage the coordinated development of the Amazon region and to allow for the equitable dispersement of the benefits of any development. The agreement was adopted in 1978. The contracting parties are Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname, and Venezuela. Under the provisions of the treaty, the parties agree to carry out joint actions that promote development, provide equitable benefits, rationally utilize the natural resources, and preserve the environment. Freedom of navigation is guaranteed and efforts at improving navigation are to be undertaken. Rational use of the water resource is encouraged, but sovereign rights are declared for the use of natural resources within each state. Scientific research and joint studies and measures on the harmonious development of the Amazon territories are to be conducted. The treaty calls for the conservation of the ethnological and archeological wealth of the region. An Amazonian Cooperative Council meets annually and supervises the treaty implementation.

U.S. Bilateral Freshwater Agreements

The United States has seven major bilateral river and lake agreements with its neighbors, three with Canada and four with Mexico. The first bilateral water agreement with Canada was the Treaty Between the United States and Great Britain Relating to Boundary Waters and Questions Arising along the Boundary Between the United States and Canada. This agreement was signed in 1909. The treaty creates a framework to settle questions between the United States and Canada resulting from their common border and designs guidelines concerning the use of boundary waters. The treaty created the International Joint Commission (IJC), which has authority over cases involving the use or diversion of boundary waters. Besides studying and arbitrating conflicts over boundary waters, the IJC is also active in conflicts over transboundary pollution, such as acid rain.

The Treaty Between the United States of America and Canada Relating to Cooperative Development of the Water Resources of the Columbia River Basin was signed in 1961. The objective of the treaty is to increase the hydrological potential of the Columbia River by building dams, reservoirs, and hydroelectrical facilities and to equitably share the resulting electrical power. Canada agrees to provide water storage and the United States agrees to construct and operate water facilities to harness the hydroelectrical potential of the stored water. Both countries agree not to divert water for purposes other than consumptive uses that may alter the water flow

as it crosses the border. The IJC has jurisdiction over the treaty implementation, although there is no enforcement mechanism.

The Agreement Between the United States and Canada on Great Lakes Water Quality was signed in 1978 and amended in 1983 and 1987. The goal of the agreement is to improve and preserve the chemical, physical, and biological integrity of the Great Lakes Basin ecosystem. By setting ambient levels for particular substances, the framers sought to ensure that the waters were free of compounds that are toxic to humans, animals, or aquatic life. Additional measures are required to control pollution from municipal, industrial, agricultural, shipping, dredging, or airborne sources if the current treatment does not meet the ambient standards. The IJC helps to coordinate and implement the agreement, although, as with the Columbia River Basin agreement, the treaty provides no enforcement mechanism.

There are four primary bilateral water agreements between the United States and Mexico, dating back over 100 years. The 1889 Convention Between the United States and Mexico to Facilitate Carrying Out the Principles Contained in the Treaty of November 12, 1884 created the International Boundary Commission, whose purpose is to arbitrate boundary disputes that arise due to riverbed changes of the Rio Grande or the Colorado River. Although the Commission can make judgments on disputes, the treaty provides no enforcement mechanism.

The Convention Providing for the Equitable Distribution of the Waters of the Rio Grande for Irrigation Purposes was signed in 1906. The United States agrees to provide to Mexico a specified amount of water each year without cost. The treaty stipulates a distribution schedule, amounts to be delivered in extraordinary circumstances, and recognition of claims and obligations, although there is no dispute settlement or enforcement mechanism.

The Treaty Between the United States and Mexico on the Utilization of Waters of the Colorado and the Tijuana Rivers and of the Rio Grande was signed in 1944. A protocol relating to this treaty also dates from the same period. The objective of the treaty is to clarify the rights of the two countries with regard to the waters of the Colorado River, the Tijuana River, and the Rio Grande and to clarify other questions that are raised due to their common border. The jurisdiction of the International Boundary Commission was expanded to encompass all issues relating to the common boundary and the Commission's name was changed to the International Boundary and Water Commission (IBWC). The charge of the Commission is to develop plans for the conservation, storage, and regulation of the common waters. The Commission is also to construct, operate, and maintain the required waterworks. An order of preference for the use of the water is given; agriculture and stock raising are given second preference behind domestic and municipal uses. Diplomatic negotiations are to resolve conflicts when the Commission cannot agree, and courts and government agencies assist in treaty administration and enforcement. The related protocol stipulates that construction and use of waterworks only partially devoted to provisions of the treaty are to be carried out by agencies of the countries, not by the Commission.

The Agreement Between the United States and Mexico on a Permanent and Definitive Solution to the International Problem of Salinity of the Colorado River was signed in 1973. The treaty requires that the United States deliver to Mexico water that is not highly saline, restrict pumping of groundwater, and confront the salinity and drainage problems of the Mexicali Valley. The United States consents to deliver a specified amount of water per year of average salinity. The IBWC is charged with dispute settlement and enforcement.

Conclusions

Most of the international freshwater agreements discussed above rely on river basin commissions that plan water resource use on a basinwide scale. These commissions have a variety of charges, however, including integrated basin management, management of development projects, and collection of data. Their enforcement powers also vary. In spite of often nonbinding provisions, the treaties have encouraged cooperation that has led to common management of international fresh water resources (U.S.I.T.C., 1991).

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Appendix

Sources of Data

Demographics

Population	CIA, 1992
Population growth rate	CIA, 1992
Population density	ERS-derived figure
Urban population	World Bank, 1992, pp 278-9
Urban growth rate	World Bank, 1992, pp 278-9

Economics

Gross domestic product	World Bank, 1992, pp 222-3
GDP growth rate	World Bank, 1992, pp 220-1
GDP per capita	ERS-derived figure
Total external debt	World Bank, 1992, pp 264-5

Environment

Land area	CIA, 1992
Irrigated land	World Resources Institute, 1992a, pp 274-5
Average fertilizer use	World Resources Institute, 1992a, pp 274-5
Average pesticide use	World Resources Institute, 1992a, pp 274-5
Livestock contribution to methane	World Resources Institute, 1992a, pp 348-9
Wet rice contribution to methane	World Resources Institute, 1992a, pp 348-9
Greenhouse gas emissions	World Resources Institute, 1992b
Greenhouse gas emissions per capita	World Resources Institute, 1992b
Land protected	World Resources Institute, 1992a, pp 298-9
Number of known threatened animal species	World Resources Institute, 1992a, pp 304-5
Climate	CIA, 1992
Environmental problems	CIA, 1992; World Resources Institute, 1992b
Land use chart	World Resources Institute, 1992a, pp 262-3
Water use chart	World Resources Institute, 1992a, pp 328-9
Land vulnerability chart	World Resources Institute, 1990, pp 286-7
GDP chart	World Bank, 1992, pp 222-3

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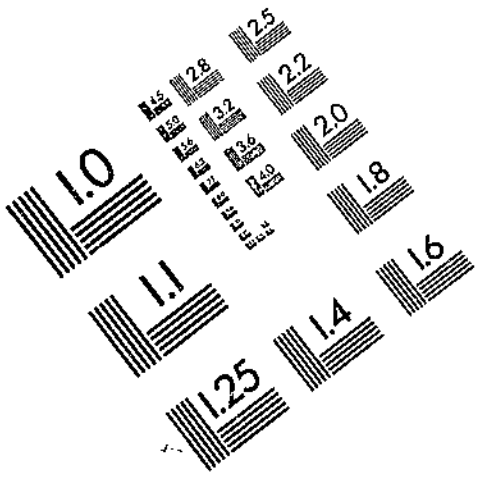

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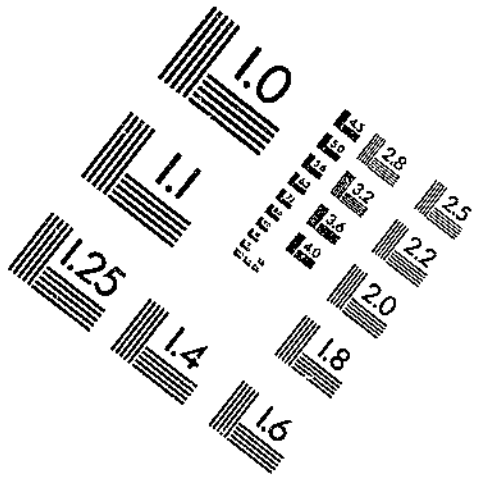

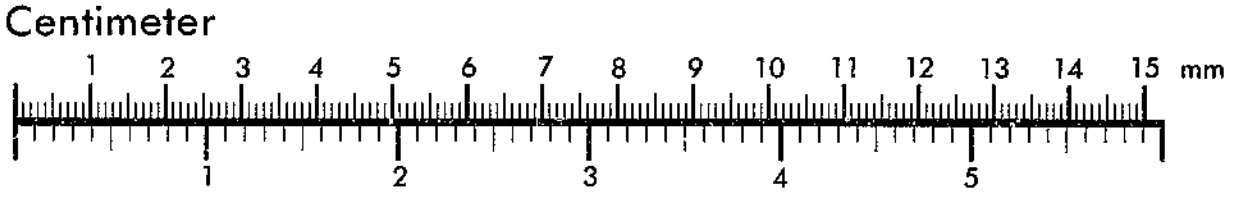

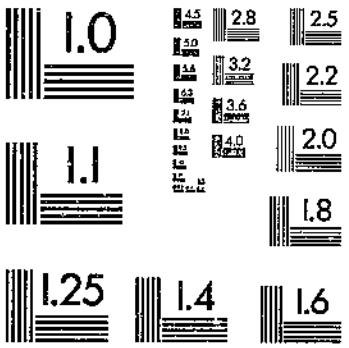

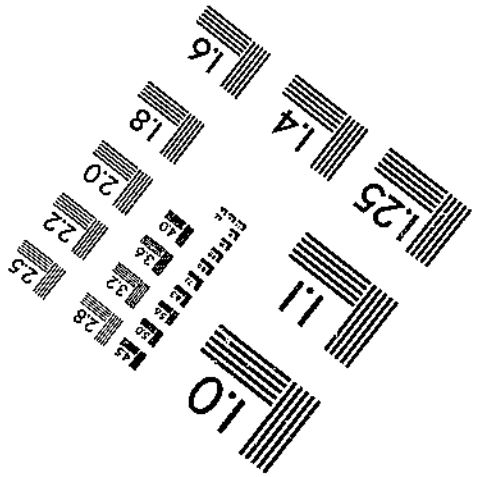

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