Nepal

GEOGRAPHY, CLIMATE AND POPULATION

Geography

Nepal is located entirely in the Ganges basin and is bordered by India in the east, south and west and by China in the north. With fifteen peaks higher than 7 000 m, including the world's highest peak Mount Everest at 8 848 m, Nepal is one of the highest countries in the world. The total land area is 147 180 km^2. Physiographically, the country can be divided into three parts: the high Himalayas in the north (24 percent of the country's total area); the hill and mountain slopes in the centre (56 percent), which include the lower hills called *siwalik* where elevations vary between 300 and 700 m; and the plain called *terai* in the south at elevations below 300 m (20 percent). For administrative purposes, the country is divided into five development regions and 75 districts.

The cultivable area is about 4 million ha, of which 34 percent in the *terai*, 8 percent in the *siwalik*, 48 percent in the mountain and hill region and 10 percent in the high Himalayas. In 2009, the total cultivated area was around 2 520 000 ha, of which 95 percent (2 400 000 ha) were for annual crops and 5 percent (120 000 ha) for permanent crops (Table 1).

Climate

Extremely varied topography within a small width ranging from 145 to 241 km influences the weather and climate. The country experiences tropical, meso-thermal, micro-thermal, taiga and tundra types of climate. The mean annual rainfall is 1 500 mm, with a maximum annual rainfall record of 5 581 mm in 1990 at Lumle in Kaski district (elevation 1 740 m) in the mountain region; and a minimum record of 116 mm in 1988 at Jomsom in Mustang district located at 2 744 m in the Kaligandi river valley near the Annapurna Himalayan range.

There are two rainy seasons: one in the summer (June to September), when the southwest monsoon brings more than 75 percent of the total rainfall, and the other in winter (December to February), accounting for less than 25 percent of the total. With the summer monsoon, rain first falls in the southeast and gradually moves west with diminishing intensity. Thus, more rain naturally occurs in the east. On the other hand, during winter, rain occurs as a result of westerly disturbances. This rain first enters Nepal in the west and gradually moves east with diminishing intensity.

The temperature decreases from the lowland *terai* (northern part of the Ganges plain) to the high Himalayan region. The extreme temperatures recorded show that in Lomangtang (Mustang district) located at an elevation of 3 705 m the minimum temperature was -14.6 °C in 1987, while in Dhangadhi (Kailali district) located at an elevation of 170 m the maximum temperature was 44 °C in 1987. Precipitation falls as snow at elevations above 5 100 m in summer and 3 000 m in winter. Temperature is a constraint on crop production in the Himalayas and the mountain region where only a single crop per year can be grown. On the other hand, in the *terai* three crops a year are common where the water supply is adequate. Single rice cropping is possible up to elevations of 2 300 m while double rice cropping is limited to areas below 800 m.

Legend

- International Boundary
- Administrative Boundary
- Capital, Regional Capital, Town
- River
- Canal
- Lake
- Dam
- Zone of Irrigation Development
- Mountain Peak

0 500 1,000 2 000 3 000 km

Albers Equal Area Projec ion, WGS 1984

NEPAL

FAO - AQUASTAT, 2011

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TABLE 1
Basic statistics and population

Physical areas			
Area of the country	2009	14 718 000	ha
Cultivated area (arable land and area under permanent crops)	2009	2 520 000	ha
• as % of the total area of the country	2009	17	%
• arable land (annual crops + temp fallow + temp meadows)	2009	2 400 000	ha
• area under permanent crops	2009	120 000	ha
Population			
Total population	2009	29 433 000	inhabitants
• of which rural	2009	82	%
Population density	2009	200	inhabitants/km^2
Economically active population	2009	12 605 000	inhabitants
• as % of total population	2009	43	%
• female	2009	45	%
• male	2009	55	%
Population economically active in agriculture	2009	11 721 000	inhabitants
• as % of total economically active population	2009	93	%
• female	2009	48	%
• male	2009	52	%
Economy and development			
Gross Domestic Product (GDP) (current US$)	2009	12 531	million US$/yr
• value added in agriculture (% of GDP)	2009	34	%
• GDP per capita	2009	426	US$/yr
Human Development Index (highest = 1)	2010	0.429	
Access to improved drinking water sources			
Total population	2008	88	%
Urban population	2008	93	%
Rural population	2008	87	%

Population

In 2009, the total population was 29.4 million, of which almost 83 percent were rural (Table 1). In 1998, the total population was about 23.3 million (82 percent rural), meaning an average annual demographic growth rate of 2.1 percent for the period 1999-2009. In 2009, population density was 200 inhabitants/km^2. In 1991, highest population density was in the capital district Kathmandu, 1 710 inhabitants/km^2, and in Bhaktapur district near the capital, 1 454 inhabitants/km^2. Lowest density was in Manang district (a Himalayan valley) with 2.4 inhabitants/km^2. In 1991, 8 percent of the total population was living in the mountain region, 45 percent in the hill region and 47 percent in the *terai* region.

In 2008, access to improved drinking water sources reached 88 percent (93 and 87 percent for the urban and rural population respectively).

ECONOMY, AGRICULTURE AND FOOD SECURITY

In 2009, the total population economically active in agriculture was around 11 721 000 inhabitants (93 percent of economically active population), of which 48 percent were women. In 2009, gross domestic product (GDP) was US$12 531 million and agriculture accounted for 34 percent of GDP (Table 1).

In 1996, agriculture contributed 42 percent of GDP and employed 93 percent of the economically active population. The main agricultural exports were pulses, jute and rice.

WATER RESOURCES AND USE

Water resources

Average annual precipitation is an estimated 1 500 mm (Table 2). Nepal has more than 6 000 rivers, which provide a dense network with steep topographic conditions. All rivers in Nepal drain into the Ganges river. The country is divided into five river basins, which are from west to east:

- Mahakali river basin, which is shared with India, with an average flow from the Indian tributaries into the border river, of arounds 15 km^3/year and some 3.4 km^3/year from the Nepalese tributaries.
- Karnali river basin, with an average outflow of about 43.9 km^3/year.
- Gandaki river basin, with an average outflow of roughlys 50.7 km^3/year;
- Kosi river basin, with an average outflow estimated as 47.2 km^3/year, which receives a contribution of some 12 km^3/year from the upper catchment area located in China; and the
- southern river basins, which produce some 65 km^3/year of water flowing into India.

The seasonal distribution of flow is extremely variable. It might be as low as 1.5-2.4 percent of the total runoff in January, February and March, and as high as 20-27 percent in July and August for snowfed rivers, while the corresponding figures for purely rainfed rivers are 0.5-3 percent from March to May and 19-30 percent in July and August.

The surface water resources produced internally are estimated as 198.2 km^3/year. The groundwater resources have not been fully assessed. Ongoing studies show that a good potential for groundwater extraction exists, especially in the southern *terai* lowland plains and inner valleys of the hilly and mountainous regions. Much of the *terai* physiographic region and some parts of *siwalik* valleys are underlain by deep or shallow aquifers, many of which are suitable for exploitation as sources of irrigation water. A rough estimate can be made by assuming a groundwater resource equivalent to 10 percent of surface water, i.e. approximately 20 km^3/year, which corresponds to the base flow of the rivers. The total internal water resources would therefore amount to 198.2 km^3/year. Chinese statistics mention an average outflow to Nepal of 12 km^3/year, which brings the total renewable water resources of Nepal to 210.2 km^3/year. It is assumed that all the renewable water resources of Nepal flow out of the country to India.

In 2009, the total dam capacity was 85 million m^3, although the potential exists for at least 138 km^3. Hydroelectricity accounted for more than 96 percent of total electricity generation. The two main diversion barrages are the Kosi and Gandaki reservoirs.

International water issues

No agreements have been established with China for the sharing of water resources. A joint commission for the exploitation of the Kosi river was set up with India in 1954 and 1966, and another for the exploitation of the Gandak river in 1959. In 1996 a treaty on the Mahakali river was ratified by parliament. The treaty makes provision for equal entitlement in the utilization of water from the Mahakali river without prejudice to respective existing consumptive uses.

In September 2008, the third meeting of the Nepal-India Joint Committee on Water Resources (JCWR) took place, to resolve pending issues and facilitate the mitigation of flood problems along the Nepal-India border and to enhance bilateral cooperation in the water sector. The Pancheshwar Multipurpose Project was identified as a priority and JCWR reviewed the current status of discussions on issues related to location of the regulating dam, unit size and installed capacity

TABLE 2
Water: sources and use

Renewable freshwater resources			
Precipitation (long-term average)	-	1 500	mm/yr
	-	220 770	million m^3/yr
Internal renewable water resources (long-term average)	-	198 200	million m^3/yr
Total actual renewable water resources	-	210 200	million m^3/yr
Dependency ratio	-	5.71	%
Total actual renewable water resources per inhabitant	2009	7 142	m^3/yr
Total dam capacity	2009	85.3	million m^3
Water withdrawal			
Total water withdrawal	2005	9 787.1	million m^3/yr
- irrigation + livestock	2005	9 610	million m^3/yr
- municipalities	2005	147.6	million m^3/yr
- industry	2005	29.5	million m^3/yr
• per inhabitant	2005	359	m^3/yr
Surface water and groundwater withdrawal	2005	9 787.1	million m^3/yr
• as % of total actual renewable water resources	2005	4.7	%
Non-conventional sources of water			
Produced wastewater		-	million m^3/yr
Treated wastewater		-	million m^3/yr
Reused treated wastewater		-	million m^3/yr
Desalinated water produced		-	million m^3/yr
Reused agricultural drainage water		-	million m^3/yr

of the power plants, assessment of project benefits in terms of irrigation and power to India and Nepal and sharing of the project cost by the two sides. JCWR is setting up a Pancheshwar Development Authority (PDA) at the earliest, in accordance with Article 10 of the Mahakali Treaty for the development, execution and operation of the Pancheshwar Multipurpose Project.

In December 2008, the first meeting of the India-Nepal Joint Standing Technical Committee (JSTC) was held. During the above-mentioned third meeting of JCWR a three-tier joint mechanism was decided upon to expedite the decision-making process and implementation of decisions undertaken at the institutional interactions. Whereas a Joint Ministerial Commission on Water Resources would be headed by the Ministers of Water Resources of India and Nepal, a Joint Standing Technical Committee was formed to rationalize technical committees and subcommittees in India and Nepal that work on flood management, inundation problems and flood forecasting activities besides project specific committees on hydropower. The JSTC will be coordinating all technical committees and subcommittees under JCWR.

The fourth meeting of JCWR was held in March 2009 to discuss the issues of water resources development projects, further strengthening the ties between the two countries. India and Nepal hoped that the works on the breach closure of the Kosi barrage would be completed in time with the cooperation of the two governments. Nepal informed on the demands of local people for the maintenance and rehabilitation of Main Gandak Western Canal and flood control structures. To date, no noticeable progress has been made concerning these demands. India informed that short-term measures have already been implemented.

Water use

In 2005, total water withdrawal was an estimated 9 787 million m^3, all freshwater withdrawal, of which 98.2 percent for agricultural purposes, 1.5 percent for municipalities and 0.3 percent for industry (Table 2 and Figure 1).

Water withdrawal for the domestic sector is from different types of sources such as springs, open wells, tubewells, rivers or streams, traditional stone taps and modern piped systems.

IRRIGATION AND DRAINAGE DEVELOPMENT

Evolution of irrigation development

Irrigation development in Nepal has a long history. Numerous small *raj kulos* (canals) in the government sector first appeared in and around Kathmandu valley in the seventeenth and eighteenth centuries. The first large public sector irrigation canal system (the Chandra Canal System) with a net command area of 10 000 ha was constructed in 1922 and is still in operation.

The irrigation potential of the country is an estimated 2 177 800 ha (Table 3). This potential is mainly for irrigation using surface water, but some 352 050 ha are potentially irrigable from groundwater in the *terai* region; 292 600 ha from shallow tubewells (83 percent) and 59 450 ha from deep tubewells (17 percent).

In 2002, the area equipped for irrigation was an estimated 1 168 300 ha, of which 79.5 percent was irrigated by surface water, 19.2 percent by groundwater and 1.3 percent by mixed surface water and groundwater (Figure 2). Seasonal canals accounted for 58 percent of the area irrigated by surface water, permanent canals accounted for 39 percent, and ponds for 3 percent. In 1992, the area equipped for irrigation accounted for 882 400 ha and in 1982 for 583 900 ha.

In 1994, 73.9 percent of the area equipped for irrigation was irrigated by surface water, 12.4 percent by groundwater and 13.8 percent by not fully identified irrigation systems. Almost all areas using surface water are dependent on transit flow availability at the sources. Therefore, the irrigated area varies from season to season and from region to region. As far as the public schemes are concerned, 91 percent were dependent on surface water in 1994 and 9 percent on groundwater. Only 67.7 percent of the public schemes was irrigated in summer, 31.1 percent in spring and 1.2 percent in winter.

Many irrigation systems use surface irrigation (basin, furrow). Some areas in the hills and mountains use sprinkler irrigation, but no figures are available.

Irrigated areas are often classified as public irrigation systems and farmer-managed irrigation systems (FMIS). Non-formal associations have existed for a long time in almost all FMIS. Water user associations (WUAs) received legal status after the promulgation of the 1992 Water Resources Act. The WUA has now become a prerequisite for the transfer of public schemes to users. In 2008, 70 percent of the country's irrigated area fell under FMIS. In the remaining areas, some systems are being transferred completely to the WUAs for management, whereas some are being jointly managed by the government and WUAs. Farmer- and community-managed systems are found to be more efficiently managed than government-managed systems. However, the government plays a crucial role in research and development, extension services and other regulatory fiscal and non-fiscal mechanisms. At the same time, essential and emergency assistance from the government

FIGURE 1
Water withdrawal by sector
Total 9.787 km³ in 2005

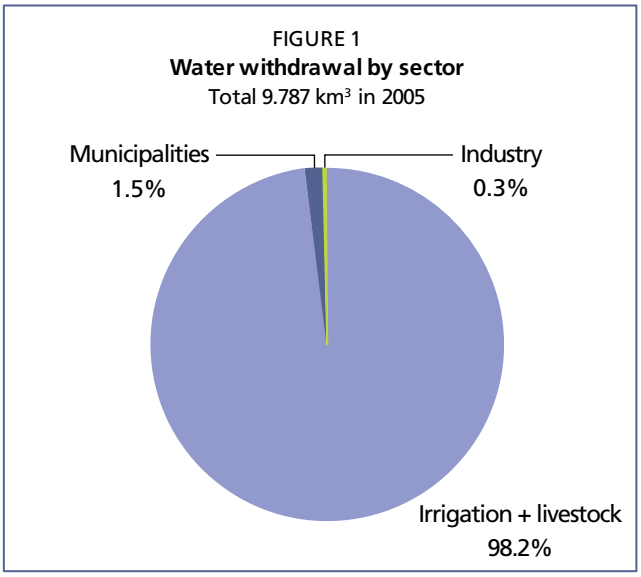
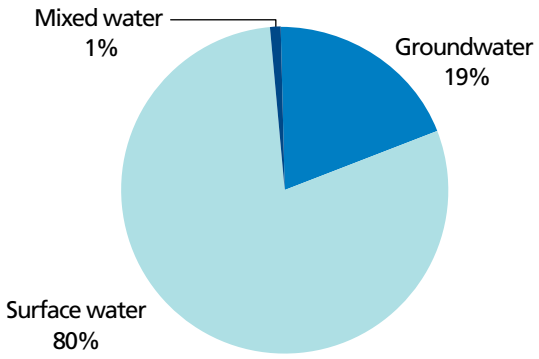


TABLE 3
Irrigation and drainage

Irrigation potential	-	2 178 000	ha
Irrigation			
1. Full control irrigation: equipped area	2002	1 168 300	ha
- surface irrigation		-	ha
- sprinkler irrigation		-	ha
- localized irrigation		-	ha
• % of area irrigated from surface water	2002	79.5	%
• % of area irrigated from groundwater	2002	19.2	%
• % of area irrigated from mixed surface water and groundwater	2002	1.3	%
• % of area irrigated from non-conventional sources of water		-	%
• area equipped for full control irrigation actually irrigated		-	ha
- as % of full control area equipped		-	%
2. Equipped lowlands (wetland, ivb, flood plains, mangroves)		-	ha
3. Spate irrigation		-	ha
Total area equipped for irrigation (1+2+3)	**2002**	**1 168 300**	**ha**
• as % of cultivated area	2002	47	%
• % of total area equipped for irrigation actually irrigated		-	%
• average increase per year over the last 10 years	1992-2002	2.85	%
• power irrigated area as % of total area equipped		-	%
4. Non-equipped cultivated wetlands and inland valley bottoms		-	ha
5. Non-equipped flood recession cropping area		-	ha
Total water-managed area (1+2+3+4+5)	**2002**	**1 168 300**	**ha**
• as % of cultivated area	2002	47	%
Full control irrigation schemes: **Criteria:**			
Small-scale schemes < ha		-	ha
Medium-scale schemes > ha and < ha		-	ha
Large-scale schemes > ha		-	ha
Total number of households in irrigation	2002	1 997 600	
Irrigated crops in full control irrigation schemes:			
Total irrigated grain production (wheat and barley)		-	metric tons
• as % of total grain production		-	%
Harvested crops:			
Total harvested irrigated cropped area	2006	1 926 000	ha
• Annual crops: total	2006	1 926 000	ha
- Wheat	2006	629 000	ha
- Rice	2006	710 000	ha
- Maize	2006	415 000	ha
- Vegetables	2006	39 000	ha
- Sugarcane	2006	39 000	ha
- Oil crops	2006	36 000	ha
- Other annual crop	2006	58 000	ha
• Permanent crops: total		-	ha
Irrigated cropping intensity (on actually irrigated area)	2006	165	%
Drainage - Environment:			
Total drained area		-	ha
- part of the area equipped for irrigation drained		-	ha
- other drained area (non-irrigated)		-	ha
• drained area as % of cultivated area		-	%
Flood-protected areas		-	ha
Area salinized by irrigation		-	ha
Population affected by water-related diseases		-	inhabitants

FIGURE 2
Source of irrigation water on area equipped for full control irrigation
Total 1 168 300 ha in 2002



to the communities in the rehabilitation and repair of irrigation systems has to be continued to sustain the farmer-managed systems (MOIR, 2005).

FMIS can be either entirely managed by farmers or assisted by specialized agencies. In FMIS, most diversion structures are constructed from brushwood and boulders and are, therefore, temporary and often washed away during monsoon season. The canals are generally unlined and prone to damage. There is, typically, a large expenditure of labour every year to restore the systems or to maintain them. In spite of these physical limitations, FMIS have demonstrated managerial skills (at community level) that have kept them functioning and contributing significantly to Nepal's food supply.

Modernization of irrigation systems and improved water management practices could lead to a reduction in irrigation water withdrawal. On the other hand, a higher cropping intensity on the irrigated areas, which would be desirable because of the increasing need for food supply, could result in increased agricultural water withdrawal.

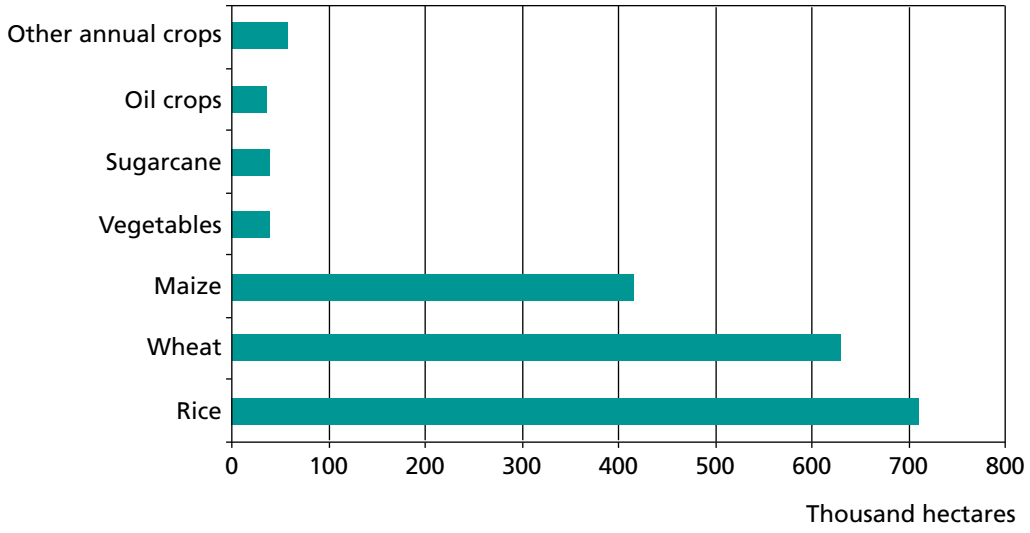
The Sunari Morang Irrigation Project (SMIP) was implemented in the *terai* of southeastern Nepal in the 1990s. It has about 65 000 ha under command of the Chatra Main Canal (CMC), which is fed from the Kosi river. The CMC, which runs from west to east, gives a gross water delivery of about 0.9 litres/s/ha, or rather less than 0.5 litres/s/ha at the plant root. This is because it was designed for supplementary irrigation, i.e. to supply enough water to supplement (by 80 percent) the monsoon rainfall, thus guaranteeing one crop of rice a year over the entire area. A series of secondary canals, running north-to-south, take the water from the CMC into the command area, which extends almost to the Nepal-India border some 20 km to the south. There is considerable conjunctive use of groundwater (STWs) and low lift pumping from drainage lines to supplement supplies from the CMC, particularly towards the tail end of the system.

The Sikta Irrigation Project is situated in the Banke district of the mid-western development region. The project, with a command area of 33 766 ha, including the rehabilitation of the Dunduwa irrigation system constructed by Indian Cooperation Mission in 1964, would irrigate almost all the lowlands of the Banke district and its economic impact could be significant for this development region. The irrigated area can be further extended by 9 000 ha. Based on the Feasibility Study Report 2004, the Government of Nepal decided to implement the project in three phases: Phase I - Construction of headworks and desilting basin; Phase II - Construction of main canal and branch canals; and Phase III - Command area development.

The Community Managed Irrigated Agriculture Sector Project (CMIASP) is the follow-up programme to the Irrigation Sector Project (ISP) and the Second Irrigation Sector Project (SISP) in 35 districts of the eastern and central development regions. The overall goal of the project is to promote inclusive economic growth while reducing poverty in the rural areas. Its specific objective is to improve agricultural productivity and sustainability of existing small- and medium-size FMIS suffering from low productivity and incidence of high poverty. To achieve the objective, the project will

1. provide improved means to empower WUAs, for irrigation facilities, agricultural extension, and targeted livelihood enhancement to build the human capital of the poor, including women and traditionally neglected disadvantaged groups; and

FIGURE 3
Irrigated crops on area equipped for full control irrigation
Total harvested area 1 926 000 ha in 2006 (cropping intensity on full control equipped area 165%)



2. strengthen policies, plans, and institutions for more responsive service delivery and sustained impacts.

The irrigation facilities will be provided in about 210 FMIS covering the total command area of 34 000 ha (including 8 500 ha expanded command area).

In 1999, the average cost of irrigation development varied from US$2 900 to 3 700/ha for the large schemes, and from US$850 to 4 300/ha for small hill schemes. The average cost of irrigation rehabilitation varies from US$1 000 to 1 800/ha. The average cost of operation and maintenance (O&M) was about US$42/ha in the smaller schemes, and US$8-14/ha in the larger schemes.

In 2002, there were 1 997 600 households that practiced irrigation, while in 1992 there were 1 377 500.

Role of irrigation in agricultural production, economy and society

In 2006, the harvested irrigated crop area covered around 1 926 000 ha, of which 37 percent was for rice, 33 percent wheat, 22 percent maize, 2 percent vegetables, 2 percent oil crops, 2 percent sugarcane and 3 percent other annual crops (Table 3 and Figure 3).

WATER MANAGEMENT, POLICIES AND LEGISLATION RELATED TO WATER USE IN AGRICULTURE

Institutions

The major government institution currently involved in the water resources and irrigation sectors is the Ministry of Irrigation (MOIR), which is responsible for the utilization and management of water resources. It prepares plans and policies and their implementation regarding irrigation development. The MOIR includes the Department of Water Induced Disaster Prevention and the Department of Irrigation.

Other institutions with direct links to the irrigation sector are:

- Ministry of Agriculture and Cooperatives (MOAC): responsible for the formulation and implementation of agricultural and cooperative development policies and plans, agricultural research, training of farmers, transfer of modern technology, and activities to develop youth and women farmers;
- National Planning Commission (NPC): prepares plans for all sectors including irrigation;
- Water and Energy Commission Secretariat (WECS): is a Government consultative body;
- Agriculture Development Bank of Nepal (ADB/N): provides concessional loans and channels government subsidies for rural projects; and the
- Department of Hydrology and Metrology of the Ministry of Environment.

The FMIS may also be classed as institutions because they are voluntary associations of farmers who organize themselves for the building and management of irrigation infrastructure, in accordance with formal or informal rules and procedures.

Water management

Traditional water resources management is focused on the supply side where only technical solutions were considered to meet the growing demand for water. Isolated projects for irrigation, drinking water supply and sanitation, hydropower, flood control and other uses were developed. Evaluation was mainly based on economic criteria, while the environmental and social impacts were hardly considered. Independent sector authorities mostly controlled these projects on the basis of command and control. The results, so far, have not been satisfactory, resulting in inter-sectoral, inter-regional and riparian conflicts.

The formulation of the Water Resources Strategy (WRS) is based on certain identified policy principles involving integrated water resources management (IWRM). Two of the stated policy principles relevant to river basin management (RBM) are: (a) Development and management of water resources shall be undertaken in a holistic and systematic manner, relying on IWRM; (b) Water utilization shall be sustainable to ensure conservation of resources and protection of the environment. Each river basin system shall be managed holistically.

The 20-year Agricultural Perspective Plan (APP), which was adopted in 1995, focuses on ways to reduce food deficits by increasing food production. The APP gave top priority to groundwater development policy mainly by installing shallow tubewells in the *terai*. However, the farmers' requests for shallow tubewells unexpectedly declined owing to the removal of the subsidy and the weakening trend of government investment in repair and maintenance of irrigation infrastructure.

In the current Tenth Five-year Plan period (2003-2008), irrigated agriculture has been given priority by high-ranking government officials. In this plan, great emphasis is placed upon the expansion of irrigation using groundwater and small irrigation development using surface water. The plan encourages the use of shallow tubewells in *terai* and localized irrigation and rainwater harvesting for irrigation. The baseline planning document also gives priority to the empowerment of local WUAs for participatory and effective irrigation management.

Finances

Nepal is mainly a rural society, and there is a traditional belief that water is a God-given free commodity. In 1999, there was a water charge only for water used by volume in urban areas for domestic use. Irrigation water is levied as a service charge. This charge is levied only for the public irrigation systems. It varies from US$1.3 to 8/ha depending upon the type and source of supply.

Policies and legislation

Irrigation Policy No. 2060 was signed in 2003 with the purpose of: obtaining year-round irrigation through the effective use of the country's current water resources; developing institutional capacity of water users for the sustainable management of existing systems; and enhancing the knowledge, skills and institutional capacity of technicians, water users and non-governmental organizations working for the development of the irrigation sector.

The National Water Plan (NWP), approved in 2005, was prepared to implement the Water Resources Strategy (WRS), which was approved in 2002. The broad objective of the NWP is to contribute to the overall national goals of economic development, poverty alleviation, food security, public health and safety, decent standards of living for the people and protection of the natural environment. The NWP provides a framework to guide, in an integrated and comprehensive manner, all stakeholders in developing and managing water resources and water services. A set of specific short-, medium- and long-term action plans have been developed for the water sector, including for programme and project activities, investments and institutional aspects.

The Water Resources Act No. 2049 of 1992 specifies the ownership, use and priority order for the utilization of water resources, WUA constitutions, provisions of licenses and the use of water resources for hydroelectricity.

ENVIRONMENT AND HEALTH

The 1994 Environmental Action Plan provided guidelines for both IWRM and maintaining water quality at the river basin level. Since 1996/1997 the Environment Protection/ Conservation Act (EPA) has been revised, however, the task of formulating working rules and defining accountability at various levels of governance and line agencies for the implementation of the Act has not yet been completed.

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