

Myanmar



GEOGRAPHY, CLIMATE AND POPULATION

Geography

Myanmar has a total area of 676 590 km² (Table 1). The country's southern coastline lies on the Andaman Sea and to the southwest the Bay of Bengal, it is bordered by Bangladesh to the west, India to the northwest, China to the northeast and Lao People's Democratic Republic and Thailand to the east. The country is divided into seven states (*pyi ne-myar*, singular: *pyi ne*), mainly covering the hill regions: Chin, Kachin, Kayah, Kayin, Mon, Rakhine (former Arakan) and Shan; and seven divisions (*taing-myar*, singular: *taing*), covering the plains: Ayeyarwady, Bago, Magway, Mandalay, Sagaing, Tanintharyi and Yangon.

Topographically, the country can be divided into five regions. They are the northern and western mountains, the eastern plateau (Shan plateau), the central basin and coastal strip. The country is mountainous, rising to more than 5 800 m above sea level in the far north, and reaching an elevation of well over 2 000 m over much of Shan state in the northeast, and in Rakhine and Chin states in the west.

The total cultivable area is almost 18.3 million ha. Total cultivated area in 2009 was around 12.1 million ha of which 11.0 million ha or 91 percent was for annual crops and 1.1 million ha or 9 percent for permanent crops. The cultivated areas are concentrated in the Ayeyarwady river basin, while potential for further expansion lies mainly in upper Myanmar, in the Chin, Kachin and Shan states.

Climate

Myanmar's climate is tropical monsoon. Rainfall is highly seasonal, being concentrated in the hot humid months of the southwest monsoon (May-October). In contrast, the northwest monsoon (December-March) is relatively cool and almost entirely dry.

The mean annual rainfall is around 2 341 mm. The most significant regional variations are those associated with the intensity of the southwest monsoon rains. Annual rainfall ranges from as high as 4 000-6 000 mm along the coastal reaches and in the mountains of Rakhine and Tanintharyi to as low as 500-1 000 mm in the central dry zone. Intermediate levels of rainfall are found across the Ayeyarwady delta areas (2 000-3 000 mm), the Shan plateau (1 000-2 000 mm) and the transitional areas. As with the rainfall, 90 percent of the discharge flows between May and October.

Population

The total population in 2009 was 47.6 million, of which around 67 percent lived in rural areas (Table 1). With a population density of 70 inhabitants/km², Myanmar is well below the density level of other countries in South and Southeast Asia. The annual population growth rate during the period 1999-2009 was around 0.7 percent.



Legend

International Boundary	River
Administrative Boundary	Canal
Capital, Regional Capital, Town	Lake
Zone of Irrigation Development	Dam
Irrigation Scheme	

0 500 1 000 2 000 3,000 km
Albers Equal Area Projection, WGS 1984

MYANMAR

FAO - AQUASTAT, 2011

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TABLE 1
Basic statistics and population

Physical areas			
Area of the country	2009	67 659 000	ha
Cultivated area (arable land and area under permanent crops)	2009	12 135 000	ha
• as % of the total area of the country	2009	18	%
• arable land (annual crops + temp fallow + temp meadows)	2009	11 035 000	ha
• area under permanent crops	2009	1 100 000	ha
Population			
Total population	2009	47 601 000	inhabitants
• of which rural	2009	67	%
Population density	2009	70	inhabitants/km ²
Economically active population	2009	27 612 000	inhabitants
• as % of total population	2009	58	%
• female	2009	46	%
• male	2009	54	%
Population economically active in agriculture	2009	18 613 000	inhabitants
• as % of total economically active population	2009	67	%
• female	2009	48	%
• male	2009	52	%
Economy and development			
Gross Domestic Product (GDP) (current US\$)		-	million US\$/yr
• value added in agriculture (% of GDP)	2004	48.35	%
• GDP per capita		-	US\$/yr
Human Development Index (highest = 1)	2010	0.451	
Access to improved drinking water sources			
Total population	2008	71	%
Urban population	2008	75	%
Rural population	2008	69	%

Access to improved drinking water sources in 2008 was 71 percent (75 and 69 percent for the urban and rural population respectively). Access to improved sanitation reached 81 percent (86 and 79 percent for the urban and rural population respectively).

ECONOMY, AGRICULTURE AND FOOD SECURITY

The total population economically active in agriculture in 2009 was around 18.6 million, which was 67 percent of the economically active population. Of the population economically active in agriculture 48 percent are women. In 2004, agriculture accounted for 48 percent of the gross domestic product (GDP) (Table 1).

Rice is by far the main agricultural crop and has great significance for the national economy. The total harvested area in 2004 was an estimated 16 721 000 ha, of which 6 543 000 ha was rice, 2 492 000 ha peas and beans, 1 465 000 ha sesame, 655 000 ha groundnut and 511 000 sunflowers (MOAI, 2010).

WATER RESOURCES AND USE

Water resources

Myanmar is endowed with abundant water resources, but here are problems, related to their

uneven spatial and temporal distribution. The monthly distribution of river flows closely follows the pattern of rainfall, which means that about 80 percent flows during the monsoon season (May-October) and 20 percent in the dry season (November-April).

The north-south direction of Myanmar's mountain ranges is reflected in the flow of its major rivers, of which two are international. There are six river basins:

- Ayeyarwady (Irrawaddy)-Chindwin river basin, which is almost entirely located in Myanmar, drains 58 percent of the territory. It can be divided into three sub-basins: Upper Ayeyarwady, Lower Ayeyarwady and Chindwin.
- Sittaung river basin, which is also entirely located in Myanmar to the east of the downstream part of the Ayeyarwady, drains 5.4 percent of the territory.
- Thanlwin (Salween in Thailand, Nu in China) river basin drains 18.4 percent of the territory, mainly the Shan plateau in the east. The source of the river is in China and, after entering the country, forms the border with Thailand for about 110 km.
- Mekong (Lankang in China) river basin drains 4.2 percent of the territory in the far east and forms the border with Lao People's Democratic Republic. Myanmar is not a member of the Mekong River Commission.
- Rakhine (Arakan) coastal basin in the west drains into the Bay of Bengal.
- Tanintharyi (Tenasserim) coastal basin in the south drains into the Andaman Sea.

Total surface water produced internally is an estimated 992.1 km³/year. Groundwater resources have been estimated as 453.7 km³/year; but a large part of this water (about 443 km³/year) comprises the base flow of the rivers and is also accounted for as surface runoff. This gives a total internal renewable water resources (IRWR) of 1002.8 km³/year (992.1+453.7-443).

The annual inflow from other countries is about 128.186 km³: with 20 km³ coming from India, 68.74 km³ (Nu to Thanlwin) and 31.3 km³ (rivers in west Yunan) from China, and 8.156 km³ from Thailand. The Mekong river forms the over 170 km border with Lao People's Democratic Republic. The source of the river is in China, the total annual flow is 73.63 km³, half of which or 36.815 km³ can theoretically be considered as an additional external resource. The total natural renewable water resources (including flow from incoming or border rivers) are therefore an estimated 1 167.8 km³/year (Table 2).

There are two major natural lakes. The largest is Inle lake in Shan state which runs some 24 km from north to south and 13 km from east to west, covering an area of 155 km². The Indawgyi lake in Kachin state stretches about 22 km from north to south and 11 km from east to west.

The Irrigation Department, which was established to coordinate the development and management of water resources for irrigation, has constructed about 200 irrigation projects, which receive water from constructed dams, weirs and sluices. A surface water runoff of about 15.46 km³ has been stored in the constructed reservoirs and can irrigate about 1 million ha (Naing, 2005).

The implementation of the Ngamoeyeik Dam Project started in 1992-1993 and the dam opened in 1995. It is an earth embankment measuring 4 724 m by 23 m with a reservoir capacity of 0.222 km³ (MIC, 2006). The dam was built to facilitate double cropping to supply additional water to farmlands in the rainy season if necessary, to take flood prevention measures on the Ngamoeyeik creek, and to supply around 600 000 m³ of water to Yangon City daily. Arrangements are being made to supply water to Ngamoeyeik dam by building the Mahuya dam and Paunglin dam to ensure that the Ngamoeyeik dam is able to work at full capacity. Measures have been taken to generate electricity from Ngamoeyeik dam (The new light of Myanmar, 2003a).

TABLE 2

Water: sources and use

Renewable freshwater resources			
Precipitation (long-term average)	-	2 091	mm/yr
	-	1 415 000	million m ³ /yr
Internal renewable water resources (long-term average)	-	1 002 800	million m ³ /yr
Total actual renewable water resources	-	1 167 800	million m ³ /yr
Dependency ratio	-	14.1	%
Total actual renewable water resources per inhabitant	2009	24 537	m ³ /yr
Total dam capacity	2005	15 460	million m ³
Water withdrawal			
Total water withdrawal	2000	33 230	million m ³ /yr
- irrigation + livestock	2000	29 575	million m ³ /yr
- municipalities	2000	3 323	million m ³ /yr
- industry	2000	332	million m ³ /yr
• per inhabitant	2000	739	m ³ /yr
Surface water and groundwater withdrawal	2000	33 230	million m ³ /yr
• as % of total actual renewable water resources	2000	2.8	%
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

The Thaphanseik dam on the Mu river in Sagaing division, completed in 2001 is, 6 km long making it one of the largest dams in Southeast Asia. It is a multi-purpose dam, providing water for irrigation and for power for the nation's developmental needs. The dam enables year-round irrigation of over 200 000 ha with feeder canals extending to eight townships (Earth Snapshot, 2009).

The Sedawgyi dam, used for hydropower, is on the right bank of the Chaunginagyi river and has a capacity of 25 MW; it became commercially operational in 1989. The Ngalaik dam in Pyinmana township was completed in 1987, with a full capacity of 0.093 km³. The Chaungmagyi dam for irrigation, also in Pyinmana township, was completed in 2003 and is able to store 0.05 km³ (The new light of Myanmar, 2003b). Another important dam for irrigation is the Yezin dam with a total capacity of 0.074 km³, which is able to irrigate 6 400 ha of agricultural land.

The Kataik dam, is 71 m high with a total capacity of 0.07 km³, was constructed in 2007 in Paung township. It is able to supply water to 4 050 ha of farmland and contributes much to regional development, since local people are able to engage in double cropping (The new light of Myanmar, 2007).

According to studies by the United Nations and other sources, the hydropower potential of Myanmar is estimated to be as much as 40 000 MW. By 2002, 35 hydropower stations (including 15 medium-scale projects) had been completed with a total capacity of 390 MW, which is just 1 percent of the potential.

The government signed an agreement with China Power Investment Corporation in 2007 for the construction of seven large dams along the Ayeyarwady, Mali, and N'Mai rivers in Kachin state. The largest one, the Myitsone dam, will be located at the confluence of the Mali and N'Mai rivers, which then become the Ayeyarwady river and will be 152 m high with an

installed capacity of 6 000 MW. The reservoir will flood an area larger than Singapore in one of the world's most disputed biodiversity 'hotspots'. An estimated 10 000 people will have to be displaced (BRN, 2010).

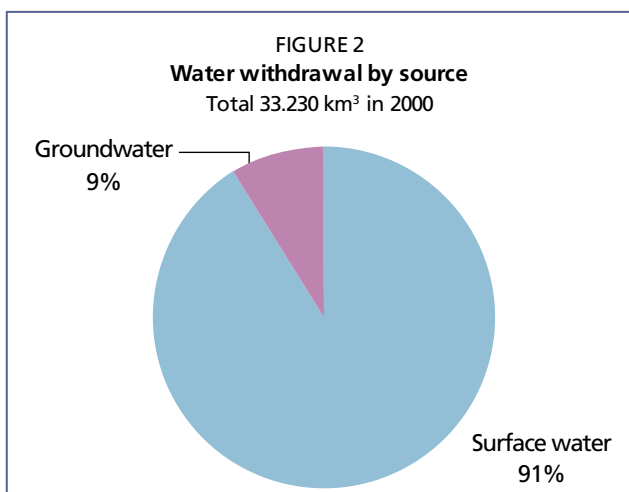
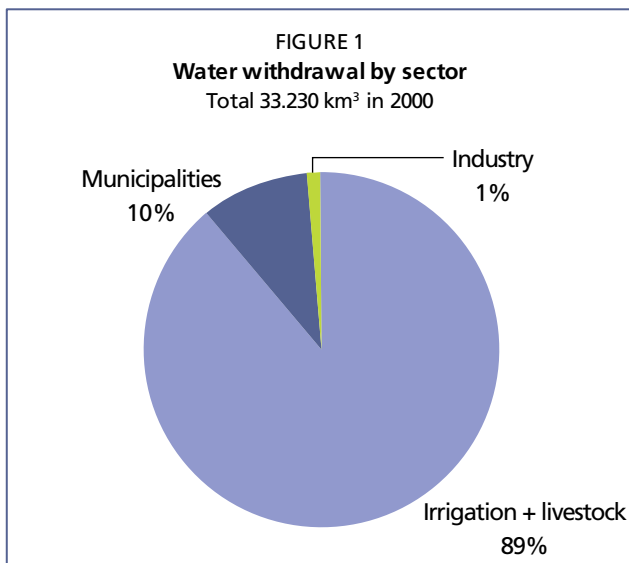
Two important hydropower dams, the Hatgyi and Tasang dams, are proposed to be constructed on the Thanlwin river (BRN, 2009).

Yangon wastewater treatment plant has been operational since 2005 and is designed to treat 12 300 m³/day (Than, 2010).

Water use

The total water withdrawal in 2000 was about 33.23 km³, of which around 29.58 km³ (89 percent) for agriculture, 3.32 km³ (10 percent) for municipalities and 0.33 km³ (1 percent) for industries (Table 2 and Figure 1).

Approximately 30.24 km³, or 91 percent of the total water withdrawal, comes from surface water and 2.99 km³, or 9 percent, from groundwater (Figure 2). Groundwater is mostly used for domestic purposes.



International water issues

The Mekong River Commission (MRC) came into existence on 5 April 1995 on agreement between the governments of Cambodia, Lao People's Democratic Republic, Thailand and Viet Nam. These four countries signed the "Agreement on the cooperation for the sustainable development of the Mekong River Basin" and agreed on joint management of their shared water resources and development of the economic potential of the river. The MRC was established on the foundation of nearly 50 years of knowledge and experience in the region, starting in 1957 as the United Nations-founded Mekong Committee. In 1996, China and Myanmar became Dialogue Partners of the MRC and the countries now work together within a cooperation framework.

The proposed Hatgyi and Tasang dams would generate electricity that would mostly be bought by Thailand, and Thai and Chinese companies are involved in the construction. The construction of the dams in Myanmar on the Thanlwin river could displace thousands of ethnic minorities (Karen), which might have to flee into neighbouring Thailand. Damming the Thanlwin has also raised environmental concerns, both in Myanmar and in upstream China. It is said that the projects would threaten one-third of the 75 fish species in the river. In 2004, China announced the suspension of all projects on the upstream Nu river pending further scientific study.

IRRIGATION AND DRAINAGE DEVELOPMENT

Evolution of irrigation development

Because of the rainfall and hydrological patterns, the need for irrigation is highest in the central dry zone, while in the delta there is more concern about drainage and flood protection.

It is thus logical that the first irrigation works should have been undertaken near Bagan (Pagan) in the central region in the eleventh and twelfth centuries. They were typically composed of diversion systems on tributaries of the middle Ayeyarwady, and were designed to provide security to the main season rice crop. Storage reservoirs were also constructed for the same purpose. The ancient systems were subsequently modernized, extended and operated in the traditional manner, with a greater emphasis on the upgrading and development of the existing flood protection and drainage facilities in the Ayeyarwady delta. This enabled the development of rice cultivation and made Myanmar a major rice-exporting country before the Second World War. Dam construction and irrigation network implementation were significantly accelerated in the 1960s, 1970s and after 1990. The irrigation potential, considering both water and soil resources, is about 10.5 million ha .

In 1986 the Ye-U irrigation rehabilitation and modernization project was approved. The main objective of the project was to rehabilitate and modernize the Ye-U irrigation and drainage system commanding 49 370 ha in the Mu river basin, located in the central dry zone, mainly to increase the production of rice in the area (World Bank, 1995).

The total area equipped for irrigation in 2004 was an estimated 2 110 000 ha (MOAI, 2010). In 2000 and 1995 was around 1 841 000 ha and 1 555 000 ha respectively.

Irrigated areas were traditionally supplied by water from weirs used to divert rivers or dams and tanks. Since the 1980s, however, there has been substantial development of wells and water is pumped from rivers. Other types of irrigation water supply include windmills, watermills, watering with buckets, ponds, etc. In 2000, out of the total irrigated area of 1 841 000 ha, 31 percent was supplied by canals (57 percent managed by the government and 43 percent by farmers), 11 percent was supplied by tanks (93 percent managed by the government and 7 percent by farmers), 4 percent by tubewells, 46 percent by pumps and 8 percent by other types of irrigation water supply (Fujita and Okamoto, 2006). Water resources for pump lift irrigation are mainly based on the flow of three major rivers, the Ayeyarwady, Chindwin, and Sittaung. Further expansion of electric pumping, however, still remains constrained, owing to limited supply of electricity (MOAI, 2010).

All irrigation in Myanmar is surface irrigation. Sprinkler and localized irrigation have been developed only on pilot farms, and altogether do not exceed 50 ha.

There are two types of irrigation management in Myanmar: public and private schemes. Government schemes account for 53 percent of weir schemes and 81 percent of the dams and tanks (all dams of and above 6.1 m). Wells and pump irrigation, although possibly originally implemented by the services of the former Ministry of Agriculture, are mainly private.

Although farmers are responsible for implementation, management, operation and maintenance of the private schemes, both the Irrigation Department and the Water Resources Utilization Department provide technical and financial assistance.

There are important groundwater aquifers in Myanmar. Their exploitation, however, has been limited to municipal water supply and to the intensive irrigation of vegetables and other high-value crops from hand-dug wells. In the central dry zone, where most of the potential for

economical run-of-the-river diversion schemes has been used, dams for surface water irrigation projects, as well as groundwater irrigation projects, were started in the 1980s. Irrigation from groundwater was practised on 55 175 ha in 1995, mainly for cotton, wheat, beans and pulses (Table 3 and Figure 3). Groundwater is drawn using diesel pumps (77 percent of the area), followed by electric pumps (15 percent) and artesian wells (8 percent). Generally, one tubewell allows supplementary irrigation on 4 ha. The groundwater irrigation area increased to 81 000 ha in 2000 and 100 000 ha in 2003 (Irrigation Department, 2004).

In the Myanmar classification of cultivated areas, inland valley bottoms that are equipped for irrigation are generally known as *maye* land, and, in 1995, were estimated at around 27 000 ha. To generate increased rice production, a combination of rice and fish farming, on plots of 1-2 ha protected by embankments, has been introduced into *maye* land areas, where rice yields were uncertain. Another type of water management is called *kaing* land in the Myanmar classification (flood recession cropping). This land, which is mainly in the Ayeyarwady delta are mostly cultivated with vegetables.

Role of irrigation in agricultural production, economy and society

Jute used to be the second most widely cultivated crop (after rice), but it has now been replaced by cash crops such as beans, pulses, sunflowers, chilies and vegetables. In 2006, total harvested irrigated cropped area was an estimated 2 722 000 ha, of which the most important crops are rice accounting for 1 861 000 ha (68 percent), pulses 284 000 ha (10 percent), wheat 89 000 ha (3 percent), cotton 85 000 ha (3 percent) and sugarcane 79 000 ha (3 percent) (Table 3 and Figure 4).

Rice is currently cultivated on 6.54 million ha (of which 1.25 million ha irrigated), comprising 4.90 million ha in the rainy season and 1.64 million ha in the dry season. Rice is mostly found in the delta and central dry zone areas. Supplemental irrigation is supplied for the rainy season rice cultivation mainly in the Mandalay, Sagaing and Magway regions, which are located in the central dry zone of Myanmar, where the rainfall is insufficient for the crop-water requirement. Other upland crops are cultivated there in the dry season using irrigation.

About 60 percent of the delta region, including the Ayeyarwady, Bago and Yangon region of Lower Myanmar, is cultivated with rainfed rice. Dry season rice is mostly cultivated in Lower Myanmar using irrigation. Rice cultivation has increased from 4.78 million ha in 1988 to 6.54 million ha in 2003, and production from 12.96 million tonnes to 22.79 million tonnes. Rice exports increased to 1 million tonnes in 2004. According to national planning targets, the sown area of rice will be expanded to 7.29 million ha (Naing, 2005).

Among other major upland crops are pulses and oilseeds. Pulses are cultivated for export and the cost of cultivation is relatively inexpensive. As a result of the increasing demand for both domestic consumption and export, the cultivation of pulses has increased from 0.73 million ha in 1988 to 3.31 million ha in 2003, of which 0.28 million ha are irrigated, production has increased from 0.5 million tonnes to 3 million tonnes. Around 1 million tonnes of pulses are now being exported. The major oilseed crops are groundnut, sesame and sunflower and cultivation of these crops increased to 2.78 million ha in 2003 (Naing, 2005).

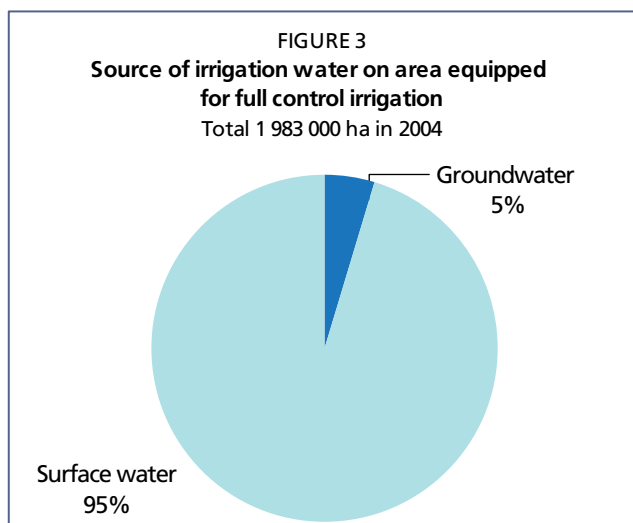
In 1999, average irrigation development costs varied from US\$2 000-8 000/ha (12 300-49 100 kyatts/ha).

Status and evolution of drainage systems

In the Ayeyarwady delta, drainage, salt intrusion and flood protection are major concerns. Embankments have been developed to protect large areas from both floods and salt intrusion. These embankments may have drainage facilities. Around 1995, there were a total of 318 flood protection works, both government (88 percent) and private (12 percent), protecting a total

TABLE 3
Irrigation and drainage

Irrigation potential		10 500 000	ha
Irrigation			
1. Full control irrigation: equipped area	2004	2 083 000	ha
- surface irrigation	2004	2 083 000	ha
- sprinkler irrigation	2000	0	ha
- localized irrigation	2000	0	ha
• % of area irrigated from surface water	2004	95.2	%
• % of area irrigated from groundwater	2004	4.8	%
• % of area irrigated from mixed surface water and groundwater		-	%
• % of area irrigated from mixed non-conventional sources of water		-	%
• area equipped for full control irrigation actually irrigated	2004	2 083 000	ha
- as % of full control area equipped	2004	100	%
2. Equipped lowlands (wetland, ivb, flood plains, mangroves)	2004	27 000	ha
3. Spate irrigation		-	ha
Total area equipped for irrigation (1+2+3)	2004	2 110 000	ha
• as % of cultivated area	2004	20	%
• % of total area equipped for irrigation actually irrigated	2004	100	%
• average increase per year over the last 9 years	1995-2004	3.45	%
• power irrigated area as % of total area equipped	1995	3.5	%
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)	2004	2 110 000	ha
• as % of cultivated area	2004	20	%
Full control irrigation schemes			
	Criteria		
Small-scale schemes	< ha	-	ha
Medium-scale schemes		-	ha
Large-scale schemes	> ha	-	ha
Total number of households in irrigation		-	
Irrigated crops in full control irrigation schemes			
Total irrigated grain production		-	metric tons
• as % of total grain production		-	%
Harvested crops			
Total harvested irrigated cropped area	2006	2 722 000	ha
• Annual crops: total	2006	2 691 000	ha
- Rice	2006	1 861 000	ha
- Wheat	2006	89 000	ha
- Maize	2006	34 000	ha
- Pulses	2006	284 000	ha
- Cotton	2006	85 000	ha
- Sugarcane	2006	79 000	ha
- Vegetables	2006	47 000	ha
- Potatoes	2006	9 000	ha
- Sweet Potatoes	2006	2 000	ha
- Tobacco	2006	1 000	ha
- Other annual crops	2006	200 000	ha
• Permanent crops: total	2006	31 000	ha
- Fruit trees	2006	31 000	ha
Irrigated cropping intensity (on full control equipped actually irrigated area)	2006	131	%
Drainage - Environment			
Total drained area	1994	193 400	ha
- part of the area equipped for irrigation drained		-	ha
- other drained area (non-irrigated)		-	ha
• drained area as % of cultivated area		2	%
Flood-protected areas		-	ha
Area salinized by irrigation		-	ha
Population affected by water-related diseases	2005	-	inhabitants



of 1.2 million ha of cultivable land. A small portion of this area (less than 10 percent) is also irrigated by small lift pumps.

In 1995, 193 363 ha were reported as being equipped with surface drainage networks. Drainage works are also considered a form of flood protection. In 1999, drainage and embankment development cost around US\$1 200/ha (7 400 kyatts/ha).

Salinization caused by irrigation is mainly found in the central dry zone, near Meiktila in Mandalay Division, where groundwater is used for irrigation.

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

Institutions

No institution is responsible for the overall management of national water resources in the public and private sectors. A proposal for establishing a Myanmar Water Commission (MWC) had been submitted to the Ministry of Agriculture and Irrigation (MOAI) for official approval.

Currently, MOAI is the main ministry involved in water resources, with the mandate to develop agriculture and irrigation. The Ministry of Agriculture was renamed the Ministry of Agriculture and Irrigation in 1996 to acknowledge the importance of irrigation for agriculture. The following departments are involved in water resources:

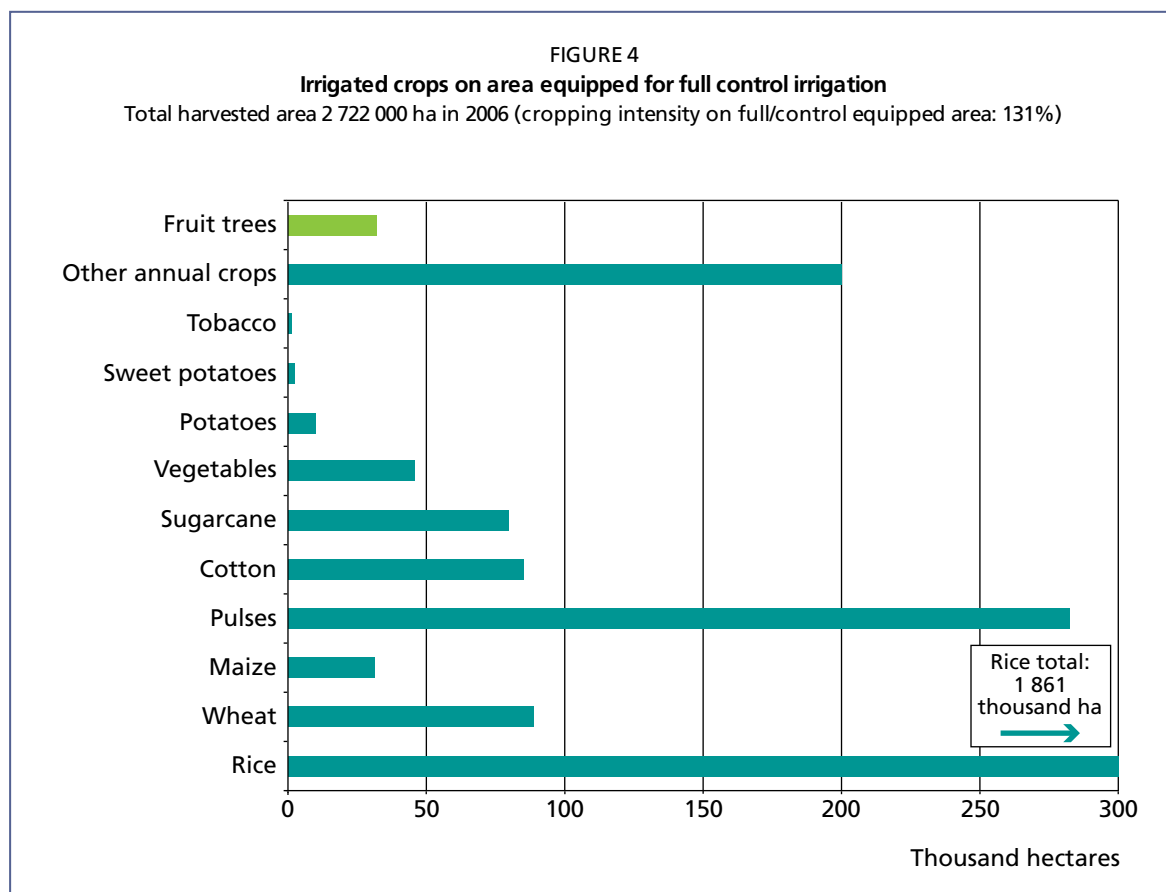
- Water Resources Utilization Department: is responsible for groundwater use (for both irrigation and rural water supply), irrigation by pumping in rivers, and the development of sprinkler and localized irrigation.
- Irrigation Department: is responsible for the operation and maintenance of irrigation works, construction of new projects, and investigation, design and implementation of proposed projects, as long as surface water is used.
- Settlement and Land Records Department: is responsible for collecting agricultural statistics and land administration.
- Agricultural Planning Department: is in charge of planning, monitoring and evaluation of all agricultural projects, including irrigation and drainage projects.

The Meteorology and Hydrology Department of the Ministry of Communication, Posts and Telegraphs is in charge of collecting hydrological and meteorological data, while the Irrigation Department has its own hydrological network. Hydropower generation is supervised by the Myanmar Electric Power Enterprise, within the Ministry of Electric Power.

Water user associations (WUAs) and water user groups (WUGs) play an important role in water management. However, the functional associations and groups are more useful for implementing irrigation works (Naing, 2005).

Water management

The Irrigation Department maintains and operates major facilities such as main dams, headworks, main canals and secondary units. Farmers maintain and operate the terminal units such as field ditches and watercourses (Naing, 2005).



The availability of adequate water for agriculture is a critical factor and is crucial for enhancing yields. MOAI has accordingly adopted five measures to raise irrigation coverage from around 20 to 25 percent of the net sown area. Emphasis is placed on the five following measures in the provision of adequate water for agricultural purposes (MOAI, 2010):

- construction of new reservoirs and dams;
- renovation of existing reservoirs to raise storage capacity and facilitate the efficient delivery of irrigation water;
- diversion of water from streams and rivulets during high water levels into adjacent ponds or depressions and for storage with sluice gates;
- lifting water from rivers and streams using pump irrigation; and
- efficient use of groundwater.

Since 1990-1991, the government has focussed on the above five strategies and the implementation of new irrigation coverage, the development of border and rural areas and greening of the dry zone. MOAI carried out appropriate works in the various states and divisions and, as a result, 170 irrigation projects were completed from 1991 to 2005 (Table 4).

Furthermore, 72 electric pump stations and 42 medium electric-pump stations were established as an alternative to irrigation provision from reservoirs. Similarly, 36 groundwater resources were tapped and made available in various locations.

No target has been fixed by the government to address concerns in the flood-protected areas; although some 400 000 ha in the delta are in need of reclamation.

TABLE 4
Government irrigation projects

State/Division	Government irrigation projects	Beneficial Area (ha)
Kayah	2	1 275
Kayin	1	40
Chin	1	202
Sagaing	18	149 714
Tanintharyi	1	Water Supply
Bago	40	253 731
Magway	31	118 712
Mandalay	42	135 392
Mon	7	25 820
Rakhine	4	182
Yangon	14	90 449
Shan	2	44 858
Ayeyarwady	7	108 224
Total	170	928 599

Starting 10-15 years ago, all new projects involving dam construction are multipurpose projects and include flood control, town water supply, hydroelectricity and irrigation. The priority for multipurpose projects with hydropower is an indicator of the expanding demand for energy.

In 2003, with the cooperation of the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) and FAO, the Irrigation Department launched a programme to develop the Myanmar Water Vision and to coordinate the establishment of a national water coordination agency (NWCA) as the principle body responsible for overall management of water resources in cooperation with both the public and private sectors.

A national level Myanmar Water Resources Committee (MWRC) is planned together with the formulation of a strategic management plan (SMP) to enhance the application of integrated water resources management (IWRM) in the country. Recently, the MOAI Inter-Ministry Task Force on Water Resources (IMTFWR) presented the Strategic Plan for IWRM, the main objective is to enhance IWRM application. The IWRM components studied when formulating the Strategic Plan were:

- principles of water resources development and management;
- operation and management;
- water allocation among competing uses and users;
- water productivity at farm, system and basin levels;
- financial resources for water source development and management;
- conjunctive use of surface water and groundwater;
- interactions between irrigation, human health and environment;
- public involvement; and
- capacity-building and human resources development.

Finances

The Irrigation Department water tariff is very low for the gravity irrigation systems, getting water from dams, and does not recover the cost of maintenance work. The annual budget for the maintenance and repair of the facilities is mostly paid for by the government. The water tariff for the river pumping systems under the Water Resources Utilization Department is higher than that of the dam systems. The water prices for rice cultivation in the dam systems are 150 and 300 times less than those of the electric and diesel type river pumping systems. As a result of the lower water price, farmers use water without caring about water shortages or water losses (Naing, 2005).

Policies and legislation

There is no single law that covers all aspects of water resources. The laws of Myanmar, however, cover many issues related to water. In particular, the roles and responsibilities of various agencies need to be developed for specific activities such as water allocation. Formulation of further legislation or decrees for proper water management is needed. All existing laws, legislation,

rules and regulations should be reviewed with the objective of enacting a unified water resources law that would allow the adoption of a more effective legal framework for coordination and management of water resources (IMTFWR, after 2004).

Since the promulgation of the Land Nationalization Act (1953), all land officially belongs to the State. However, farm households benefit from a customary usufruct right to the land.

ENVIRONMENT AND HEALTH

Sedimentation is one of the major adverse effects of storage dams and in the lower courses of rivers. Mining and deforestation along the upper reaches of river basins cause serious erosion problems. Transported sediment is reducing the storage capacity of reservoirs and the bed levels are rising in the lower reaches. Consequently, flooding occurs and navigation is problematic. Although some nutrients and some sediment are needed to support the aquatic environment, the Government is emphasizing the implementation of the terrace farming system to reduce shifting cultivation.

The development of industry and increasing population density will cause increasing river pollution and health risks for people living close to the rivers. Careful management of groundwater extraction is also required to avoid pollution (IMTFWR, after 2004).

PROSPECTS FOR AGRICULTURAL WATER MANAGEMENT

The population of Myanmar is estimated to reach 86 million by 2025, against 50 million at present. Increasingly food will be necessary for the country's growing population. Rice is the main food crop, and is one of the most important crops grown. The MOAI has the objective of achieving a surplus in rice production. Other objectives are to achieve self-sufficiency in edible oil and to set up the production of exportable pulses and industrial crops. Irrigation will have to play a major role in the development of Myanmar's agriculture sector.

The Irrigation Department plans to implement a project on "Strengthening farmers' irrigation management", together with the Myanmar Agriculture Services, the Water Resources Utilization Department and the Settlement and Land Records Department with the technical assistance of the Japanese Government. The Project objective is to reduce government administrative and maintenance costs for new irrigation projects as well as those of the existing irrigation system. The resources made available from these adjustments could be used to improve the system losses, expand the area under irrigation, and to update farm-level facilities. Farmers will voluntarily form water user associations, irrigation system management will be enforced and maintenance and repairs of irrigation facilities will be carried out. Rules, regulations and principles should be improved to ensure equitable and efficient water use and allocation (Naing, 2005).

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