Yodo-gawa

Map of River

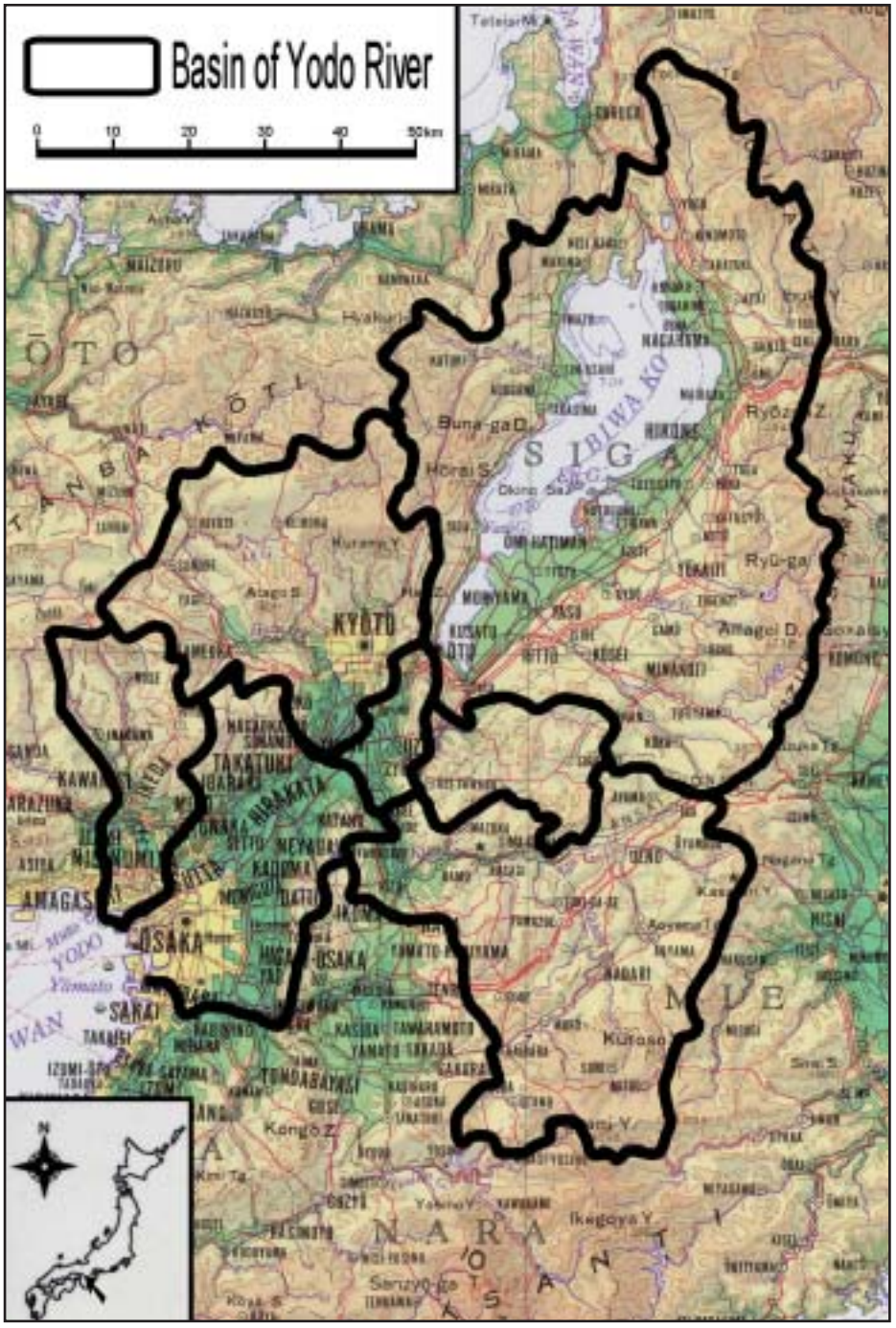


Table of Basic Data

Name: Yodo-gawa		**Serial No. :** Japan-12
Location: Honshu, Japan	N 34° 24' ~ 35° 44'	E 135° 19' ~ 136° 29'
Area: 8,240 km^2	**Length of main stream:** 75 km	
Origin: Lake Biwa	**Highest point:** Mt. Ibuki (1,377 m)	
Outlet: Osaka Bay	**Lowest point:** River Mouth (0 m)	
Main geological features: andesite, tuff, granite, schist		
Main tributaries: Uji River (506 km^2), Katsura River (1,100 km^2), Kizu River (1,596 km^2)		
Main lakes: Lake Biwa (670 km^2)		
Main reservoirs: Takayama (49.2 x 10^6m^3, 1969), Hiyoshi (58.0 x 10^6m^3, 1998), Shorenji (23.8 x 10^6m^3, 1970), Nunome (15.4 x 10^6m^3, 1992), Hinachi (18.4 x 10^6m^3, 1999), Murou (14.3 x 10^6m^3, 1974), Hitokura (30.8 x 10^6m^3, 1983)		
Mean annual precipitation: 1387.8 mm (1976 ~ 2000) at Hirakata		
Mean annual runoff: 270.8 m^3/s (1952 ~ 1998) at Hirakata		
Population: 10,630,000 (1994)	**Main cities:** Kyoto, Osaka, Otsu	
Land use: Mountainous area (71.9%), Flat area (28.1%)		

1. General Description

The 75 km long Yodo River (Yodo-gawa) system, located in the central part of Japan, is the seventh largest river basin in Japan with a catchment area of 8,240 km^2. Flowing south out of Lake Biwa, the largest lake in Japan, first as the Seta River and then the Uji River, it merges with the Kizu and Katsura Rivers near the border between Kyoto and Osaka Prefectures. The Yodo River runs through the heartland of the Kinki region and flows into Osaka Bay.

The Yodo River basin consists of six sub-catchments, which are the Lake Biwa basin (3,802 km^2), the Uji River basin (506 km^2), the Kizu River basin (1,647 km^2), the Katsura River basin (1,152 km^2), the lower Yodo River basin (521 km^2) and the Kanzaki River basin (612 km^2). It extends over the six prefectures of Shiga, Kyoto, Osaka, Hyogo, Nara and Mie.

City areas spread throughout the basin. Metropolitan areas such as Osaka, Kyoto, and Otsu are located along the rivers. The population of the basin is about 10,630,000, which is 9% of the population of Japan and 53% of that in the Kansai region. In the lower Yodo River basin, most of the heavily populated urban developments are located in areas lower than the river water level. In Osaka City, it is estimated that 94.9% of the total metropolitan area is located in flood-prone areas.

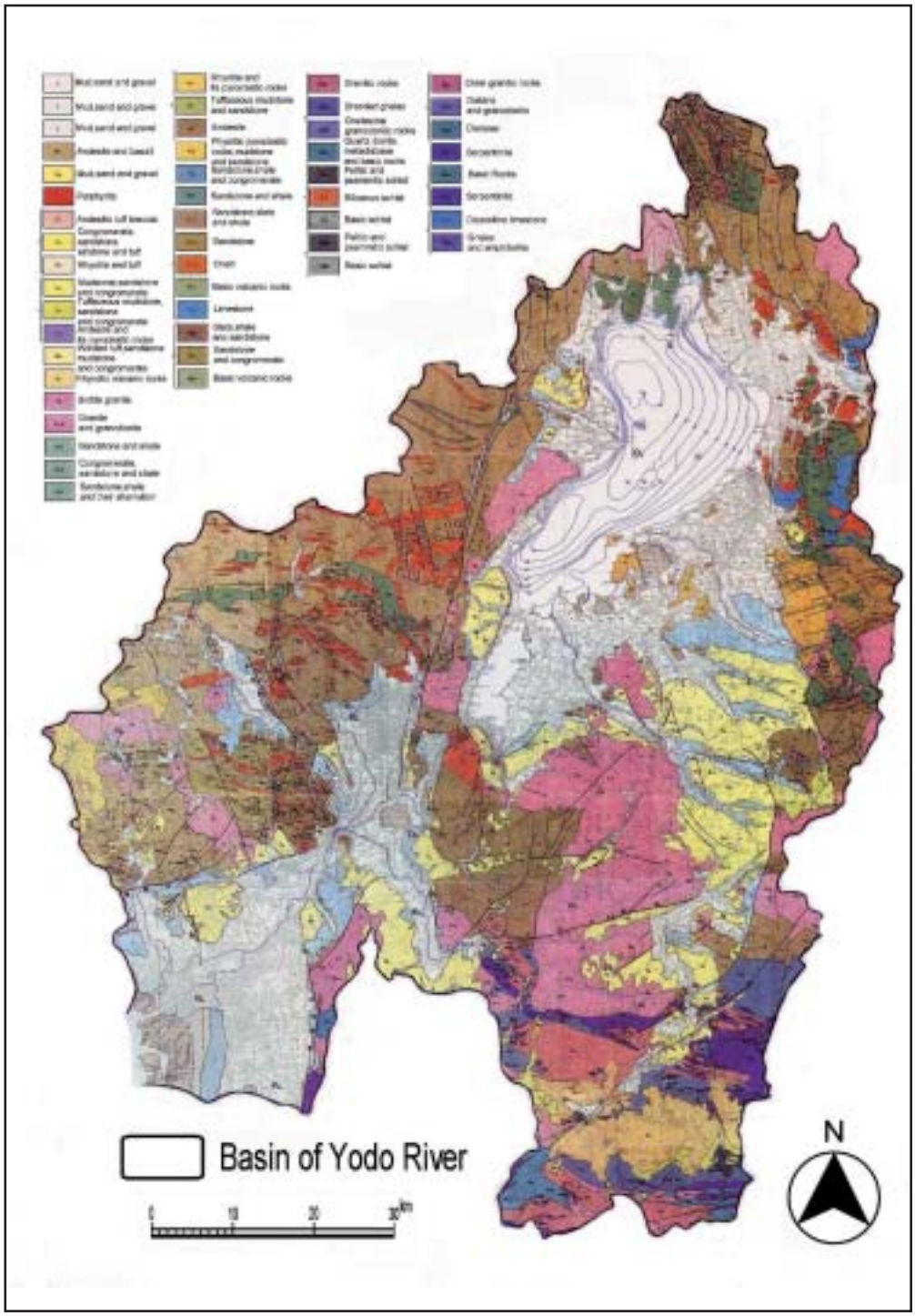
Precipitation in the basin is widely distributed in time and space. The annual precipitation of the Lake Biwa, Katsura River, Kizu River, and the lower Yodo River basins are about 1,880 mm, 1,640 mm, 1,590 mm, and 1,400 mm respectively. The mean annual precipitation of the whole Yodo River basin is about 1,600 mm.

The Lake Biwa basin, the Katsura River basin, and the Kizu River basin have high flows in the snow melt season from March to April, the rainy season from June to July, and the typhoon season from September to October, respectively.

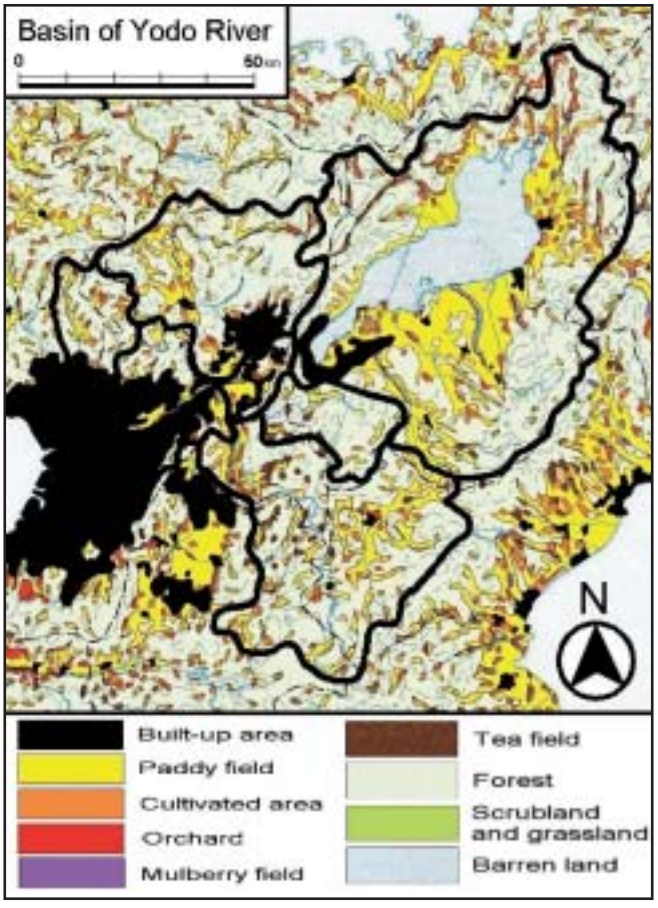
Due to the time and space dispersion of high flows in tributaries and the large storage capacity of Lake Biwa, the river flow conditions are more stable than those of other Japanese basins.

2. Geographical Information

2.1 Geological Map



2.2 Land Use Map

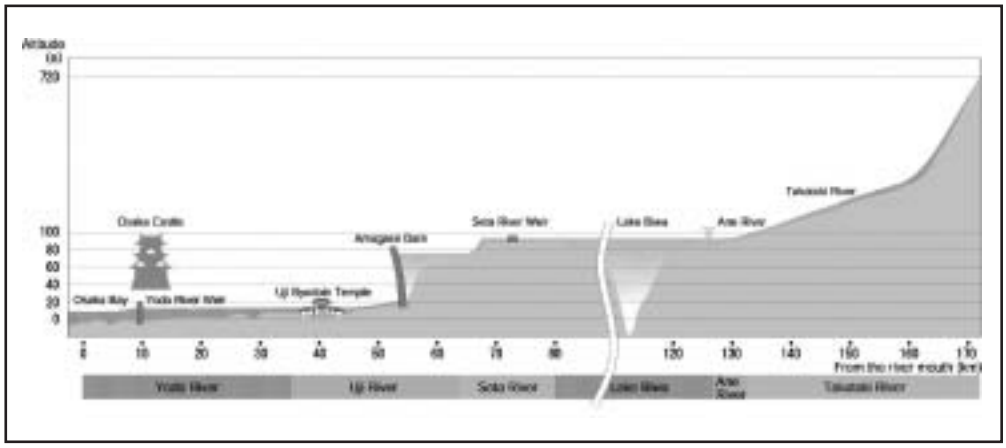


2.3 Characteristics of River and Main Tributaries

No.	Name of river	Length [km] Catchment area [km^2]	Highest peak [m] Lowest point [m]	Cities population	Land use [%]
1	**Yodo** (Main river)	37 231	Sekidougaoka 680 River mouth 0	Osaka 2,607,700	
2	**Biwa** (Lake)	- 3,802	Mt. Ibuki 1,377 Outlet 80.8	Otsu 289,601	
3	**Uji** (Tributary)	38 506	Mt. Shubu 681 Confluence 19.0	Uji 191,122	M 71.9
4	**Katsura** (Tributary)	114 1,100	Mt. Jizou 948 Confluence 17.7	Kyoto 1,467,521	F 28.1
5	**Kizu** (Tributary)	99 1,596	Mt. Kuroso 1,038 Confluence 15.8	Ueno 59,765	
6	**Kanzaki** (Tributary)	13 612	Mt. Keno 785 River mouth 0	Osaka 2,607,700	

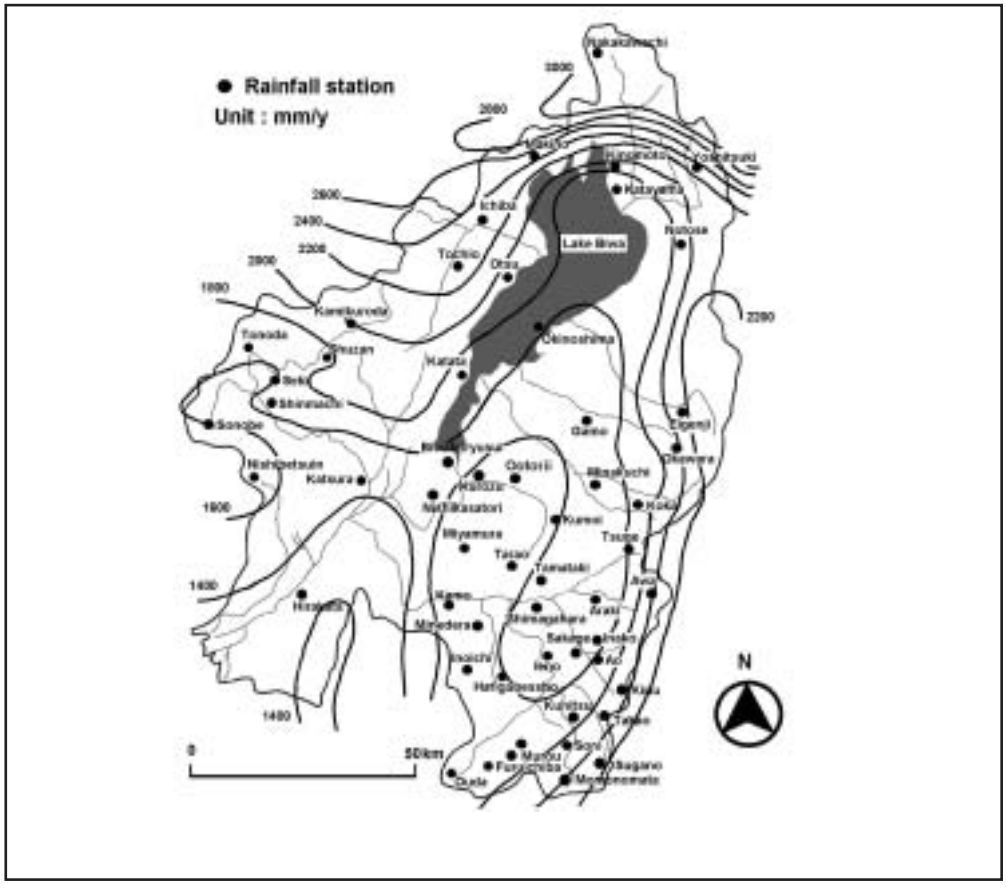
M: Mountainous area F: Flat area

2.4 Longitudinal Profiles



3. Climatological Information

3.1 Annual Isohyetal Map and Observation Stations



3.2 List of Meteorological Observation Stations[1)]

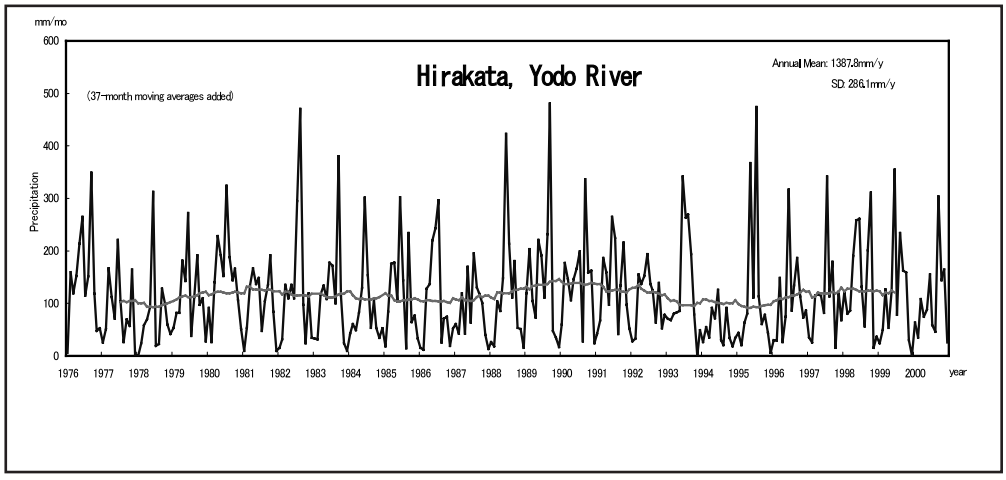
No.[2)]	Station	Elevation [m]	Location	Observation period	Mean annual precipitation [mm]	Observation items[3)]
60051	**Imazu**	88	N 35° 24' 36" E 136° 01' 54"	1974 ~ present	1,829.7 1989 ~ 1998	DS, P, T, W
60131	**Hikone**	87	N 35° 16' 24" E 136° 14' 48"	1974 ~ present	1,608.8 1989 ~ 1998	DS, P, T, W
60216	**Otsu**	86	N 34° 59' 18" E 135° 54' 54"	1977 ~ present	1,659.7 1989 ~ 1998	DS, P, T, W
53112	**Ueno**	159	N 34° 45' 30" E 136° 08' 56"	1985 ~ present	1,480.0 1989 ~ 1998	DS, P, T, W
61271	**Sonobe**	195	N 35° 03' 12" E 135° 27' 30"	1974 ~ present	1,650.4 1989 ~ 1998	DS, P, T, W
61286	**Kyoto**	41	N 35° 00' 42" E 135° 44' 06"	1974 ~ present	1,565.9 1989 ~ 1998	DS, P, T, W
62051	**Toyonaka**	9	N 34° 46' 24" E 135° 26' 54"	1974 ~ present	1,378.2 1989 ~ 1998	DS, P, T, W
62046	**Hirakata**	26	N 34° 48' 18" E 135° 40' 36"	1975 ~ present	1,453.2 1989 ~ 1998	DS, P, T, W

1) 30 rainfall observation stations managed by Japan Meteorological Agency and 27 managed by Ministry of Land, Infrastructure and Transport are operated in the Yodo River basin. Only some of the stations are listed here.
2) Serial Number used by Japan Meteorological Agency.
3) DS: Duration of sunshine, P: Precipitation, T: Air temperature, W: Wind velocity and wind direction.

3.3 Monthly Climate Data (Observation station: Osaka)

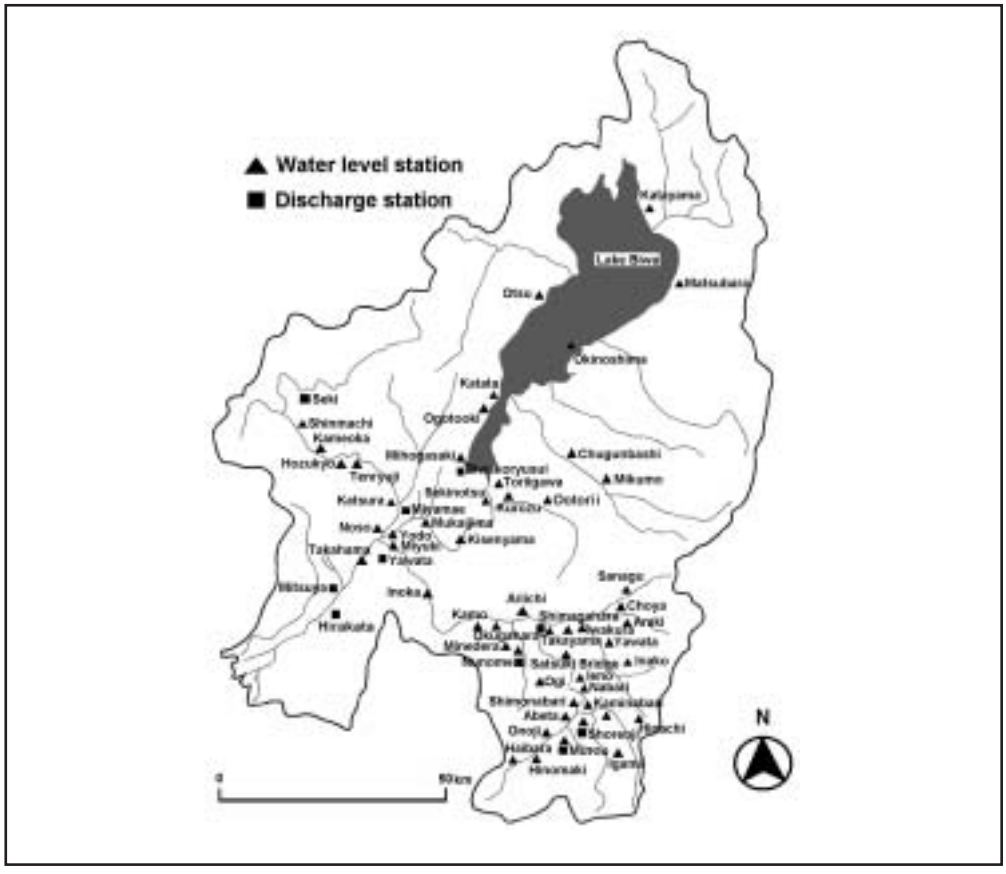
Observation item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Period for the mean
Temperature [°C]	5.8	5.9	9.0	14.8	19.4	23.2	27.2	28.4	24.4	18.7	13.2	8.3	16.5	1971~2000
Precipitation [mm]	43.7	58.7	99.5	121.1	139.6	201.0	155.4	99.0	174.9	109.3	66.3	37.7	1036.1	1971~2000
Solar radiation [MJ/m^2/day]	7.4	9.2	11.8	15.0	16.9	15.2	16.6	16.6	12.6	10.5	8.1	6.9	12.3	1971~2000
Duration of sunshine [hr]	142	131	158	183	200	150	186	211	149	162	147	149	1967	1971~2000

3.4 Long-term Variation of Monthly Precipitation



4. Hydrological Information

4.1 Map of Streamflow Observation Stations



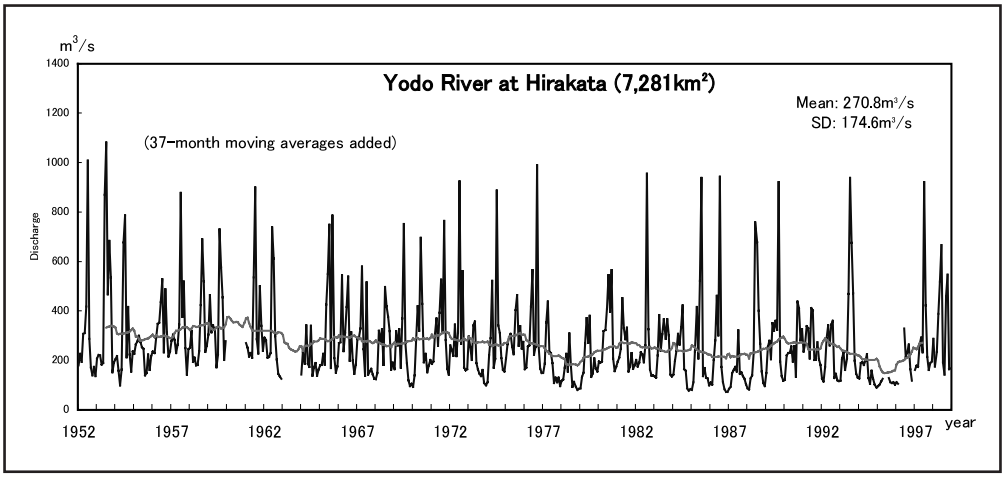
4.2 List of Hydrological Observation Stations[1)]

No.[2)]	Station	Location	Catchment area (A) [km^2]	Observation period	Observation items[3)] (frequency)
60465	**Kamo**	66.5 km from the river mouth	1,456.0	1898 ~ present	H, Q
60503	**Shinmachi**	77.9 km from the river mouth	540.0	1956 ~ present	H, Q
60582	**Gunkoubashi**	15.8 km from the river mouth	322.8	1954 ~ present	H, Q
60532	**Hirakata**	25.9 km from the river mouth	7,281.0	1955 ~ present	H, Q

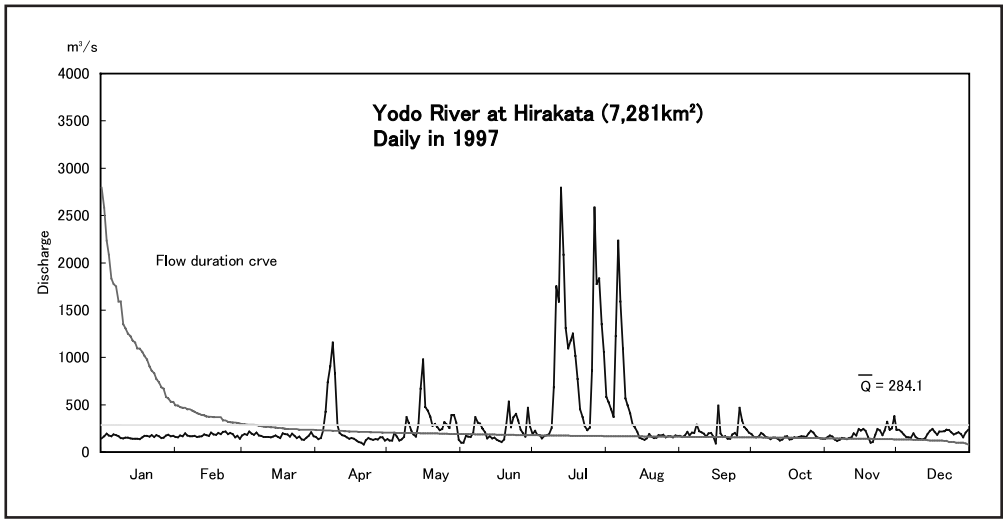
No.[2)]	$\overline{Q}$[4)] [m^3/s]	Qmax[5)] [m^3/s]	$\overline{Q}$max[6)] [m^3/s]	$\overline{Q}$min[7)] [m^3/s]	$\overline{Q}$/A [m^3/s/100km^2]	Qmax/A [m^3/s/100km^2]	Period of statistics
60465	45.56	6,200.00	1,610.31	7.13	3.13	425.82	1938 ~ 1996
60503	18.04	1,704.40	679.56	0.71	3.34	315.63	1969 ~ 1997
60582	8.53	1,571.70	613.19	0.26	2.64	486.90	1955 ~ 1996
60532	272.05	7,970.00	3,177.59	91.05	3.74	109.46	1952 ~ 1977

1) 53 water stage stations and 9 discharge stations are operated in the Yodo River basin.
2) Serial Number used by Ministry of Land, Infrastructure and Transport
3) H: water level, Q: discharge, Q is obtained from rating curve.
4) $\overline{Q}$: Mean annual discharge
5) Q max : Maximum discharge
6) $\overline{Q}$: max: Mean maximum discharge
7) $\overline{Q}$ min: Mean minimum discharge

4.3 Long-term Variation of Monthly Discharge



4.4 Annual Pattern of Discharge



4.5 Unique Hydrological Features

The Yodo River basin includes Lake Biwa, which is the largest fresh-water lake in Japan with an area of about 670 km^2 and a storage capacity of 27.5 billion m^3. The catchment area of Lake Biwa is 3,848 km^2, which accounts for 47% of the Yodo River basin. Water flows into Lake Biwa from more than one hundred rivers before being discharged into the Seta River, which is the only natural outflow river from the lake.

Lake Biwa plays an important role as a regulating reservoir for flood control. In the case of flooding of the main Yodo River, the Setagawa Weir, located at the outlet of Lake Biwa, is controlled to reduce flows to the lower basin.

Lake Biwa also has a role as the water source for the 13 million people in Kansai region. When severe drought occurs, the downstream water users, the Central Government, and relevant local governments convene a task force that coordinates drought mitigation measures. The minimum water needed by downstream areas is discharged from Lake Biwa.

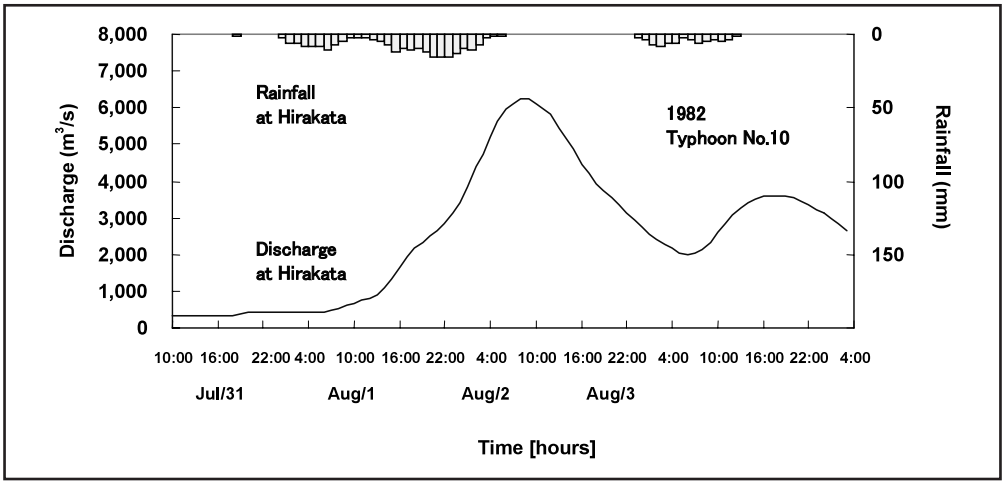
4.6 Annual Maximum and Minimum Discharges

Station: Hirakata [7,281 km^2]

Year	Maximum[1)]		Minimum[2)]		Year	Maximum[1)]		Minimum[2)]	
	Date	[m^3/s]	Date	[m^3/s]		Date	[m^3/s]	Date	[m^3/s]
1952	6.24	4,200	8.27	80.0	**1976**	9.11	3,391	2.16	103.4
1953	9.25	7,800	1.3	104.0	**1977**	3.31	1,567	10.30	75.5
1954	7.6	3,540	4.11	74.0	**1978**	6.24	2,406	10.27	65.6
1955	10.21	1,124	5.11	94.8	**1979**	6.29	2,281	1.25	70.5
1956	9.27	5,025	8.21	134.0	**1980**	7.11	1,690	11.21	112.1
1957	6.28	2,740	4.19	93.6	**1981**	10.9	1,378	8.20	106.8
1958	8.26	3,990	3.26	95.0	**1982**	8.2	6,271	7.6	103.4
1959	9.27	7,970	6.19	119.3	**1983**	9.29	3,750	6.12	99.9
1960	8.30	3,775	-*	115.0	**1984**	6.27	1,960	11.12	58.3
1961	10.28	7,206	9.14	97.8	**1985**	6.26	2,669	2.8	73.5
1962	8.26	2,615	12.28	103.2	**1986**	7.22	4,091	12.14	59.0
1963	5.18	1,801	11.29	101.1	**1987**	7.20	1,436	1.12	61.4
1964	7.20	955	8.21	94.3	**1988**	6.3	2,388	1.21	65.9
1965	9.18	6,868	8.31	93.1	**1989**	9.3	3,599	1.6	96.6
1966	7.2	2,442	11.13	113.1	**1990**	9.20	3,949	9.11	89.3
1967	7.10	3,077	6.22	95.7	**1991**	-*	-*	-*	-*
1968	8.30	1,702	2.5	93.7	**1992**	8.20	2,308	8.17	58.1
1969	7.9	2,064	12.22	81.0	**1993**	7.5	4,104	4.24	74.9
1970	6.16	2,638	1.26	73.5	**1994**	9.30	2,753	9.14	60.8
1971	9.7	2,096	11.26	112.0	**1995**	5.12	4,760	11.26	73.7
1972	9.17	5,228	10.30	110.7	**1996**	8.29	1,627	1.21	75.4
1973	5.2	1,114	8.13	75.5	**1997**	7.27	3,835	6.20	42.5
1974	7.25	2,744	1.5	93.1	**1998**	10.17	2,348	9.3	66.5
1975	8.23	2,774	1.13	94.8	**1999**	6.30	3,811	10.25	107.1

1), 2) Instantaneous observation by recording chart
* missing data

4.7 Hyetograph and Hydrograph of Major Flood



5. Water Resources

5.1 General Description

The water of the Yodo River was mainly used for agricultural water and transportation services in the past. The first water utilization canal from Lake Biwa to the Kyoto City area (the Lake Biwa Canal) was constructed in 1890 and the water was used for various purposes including the nation's first hydroelectric power generation, transportation, irrigation and public water supply. In 1912, the second water utilization canal was completed aimed at expansion of the public water supply and power generation. In the Uji River, hydroelectric power generation was developed, and the Uji power generation plant was built.

After that, the first phase of the Yodo River Water Control Works was implemented to cope with the increasing demand for water needed for the development of an industrial economy, and the water utilization started through the regulation of the water level in Lake Biwa.

In 1962 the Water Resources Development Promotion Law of Japan was used to give the Yodo River system a special designation that has since allowed various projects to be implemented. Now eight dams and two river weirs are operated for the prevention of flood disasters and for the water resources needs of the 13 million people living in the Kansai area.

5.2 Map of Water Resource Systems

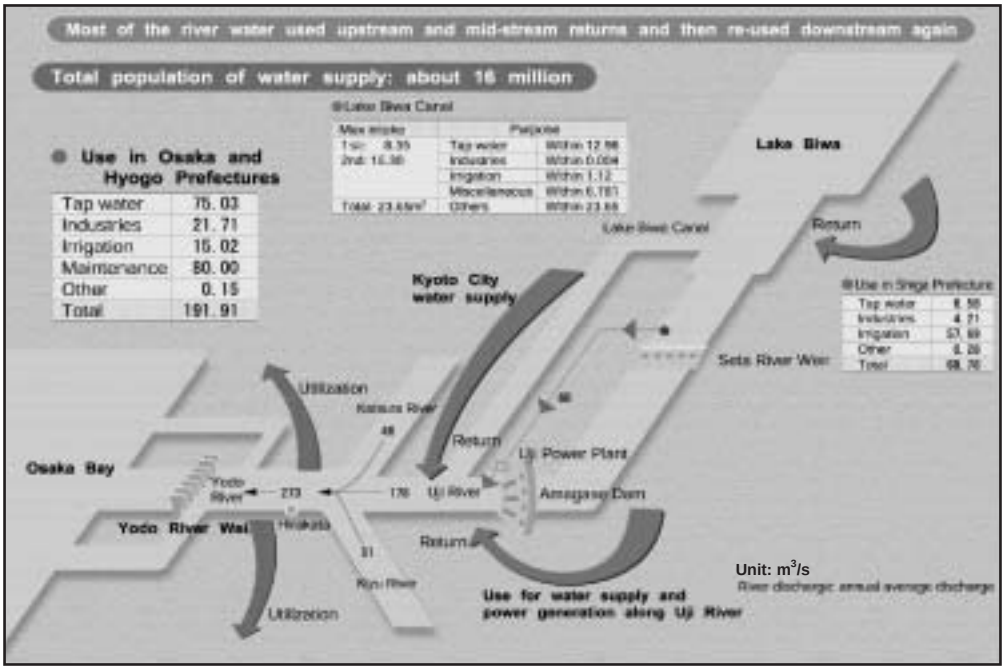
5.3 List of Major Water Resources Facilities

Major Reservoirs

Name of river	Name of dam (reservoir)	Catchment area [km^2]	Gross capacity [10^6m^3]	Effective capacity [10^6m^3]	Purpose[1)]	Year of completion
Nunome	**Nunome**	75	17.3	15.4	F, N, W	1992
Nabari	**Hinachi**	76	20.8	18.4	F, N, P, W	1999
Nabari	**Takayama**	615	56.8	49.2	F, N, P, W	1969
Katsura	**Hiyoshi**	290	66.0	58.0	F, N, W	1998
Shorenji	**Shorenji**	100	27.2	23.8	A, F, N, P, W	1970
Uda	**Murou**	169	16.9	14.3	F, N, W	1974
Ina	**Hitokura**	115	33.3	30.8	F, N, W	1983

1) A: Agricultural use F: Flood control I: Industrial use N: Maintenance of normal flows
P: Hydro-power W: Municipal water supply

Major Water Transfer



5.4 Major Floods and Droughts

Major Floods

Date	Peak discharge at Hirakata [m^3/s]	Rainfall [mm] Duration			Meteorological cause	Dead and missing	Major damages (Districts affected)
		Kizu River	Katsura River	**Uji River			
1953. 9.25	*(8,650) 7,800	261	268	265	Typhoon No.13	145	Houses totally destroyed: 2,820 Houses partly destroyed: 7,808 Houses washed away: 517 Houses inundated: 227,577
		2 days					
1956. 9.27	4,610	204	137	166	Typhoon No.15	N.A.	N.A.
		N.A.					
1958. 8.27	4,030	210	130	184	Typhoon No.17	N.A.	N.A.
		N.A.					
1959. 8.14	6,800	250	305	322	Low pressure front and Typhoon No.7	23	Houses totally destroyed: 43 Houses partly destroyed: 115 Houses washed away: 109 Houses inundated: 47,476
		3 days					
1959. 9.27	7,200	296	177	282	Typhoon No.15 (Ise Gulf Typhoon)	1,674	Houses total destroyed: 5,051 Houses partly destroyed: 13,833 Houses washed away: 1,633 Houses inundated: 137,344
		3 days					
1960. 8.30	3,840	129	265	60	Typhoon No.16 and Typhoon No.18	28	Houses totally destroyed: 47 Houses partly destroyed: 158 Houses washed away: 15 Houses inundated: 28,979
		3 days					
1961. 10.28	7,800	289	245	209	Low pressure front and Typhoon No.26	4	Houses inundated: 12,589
		4 days					
1965. 9.17	7,300	205	216	206	Typhoon No.24	11	Houses totally destroyed: 97 Houses partly destroyed: 123 Houses washed away: 2 Houses inundated: 40,268
		2 days					
1972. 9.17	5,230	167	159	158	Typhoon No.20	12	Houses totally destroyed: 55 Houses partly destroyed: 605 Houses inundated: 78,393
		2 days					
1982. 8.2	6,260	312	159	248	Typhoon No.10	49	Houses totally destroyed: 125 Houses partly destroyed: 136 Houses washed away: 9 Houses inundated: 50,201
		2 days					
1994. 9.30	2,750	178	59	113	Typhoon No.26	N.A.	Houses partly destroyed: 3 Houses inundated: 323
		4 days					
1995. 5.12	4,760	181	199	191	Low pressure front	N.A.	Houses inundated: 55
		6 days					

* Hypothetical value assuming no damage to the dike.
** Except for the Lake Biwa catchment area.

Major Droughts

Year	Rainfall - Lake Biwa catchment area (mm/month) (ratio to the average value in %)						Lake Biwa Lowest water mark	Yodo River, Hirakata Lowest flow
	Jul	Aug	Sept	Oct	Nov	Dec		
1973	50 (21)	116 (75)	181 (86)	166 (127)	71 (71)	64 (54)	-54 cm Sept. 2	80.9 m^3/ s Aug. 13
1977	68 (29)	88 (57)	165 (79)	59 (45)	165 (165)	141 (119)	-58 cm Nov. 2	82.8 m^3/ s Oct. 30
1978	41 (18)	71 (46)	195 (93)	83 (63)	95 (95)	89 (75)	-73 cm Nov. 29	73.8 m^3/ s Nov. 19
1984	183 (78)	57 (37)	98 (47)	70 (53)	45 (45)	133 (113)	-95 cm Jan. 26	68.4 m^3/ s Dec. 10
1986	360 (154)	31 (20)	95 (45)	95 (73)	60 (60)	133 (113)	-88 cm Dec. 14	65.2 m^3/ s Dec. 7
1990	176 (75)	86 (55)	450 (214)	168 (128)	234 (234)	128 (108)	-69 cm Sept. 12	73.1 m^3/ s Aug. 7
1994	25 (11)	65 (42)	305 (145)	37 (28)	53 (53)	88 (75)	-123 cm Sept. 15	52.7 m^3/ s Sept. 14

Year	Water restriction period Month/Day		No. of days with restriction	Water restriction ratio	
				Tap water	Industrial water
1973	1st.	7/31 ~	96	10%	15%
	2nd.	9/4 ~	1	20%	25%
1977	1st.	8/25 ~	134	10%	15%
1978	1st.	9/1 ~	159	10%	15%
1984	1st.	10/9 ~	154	10%	12%
	2nd.	11/6 ~	115	20%	22%
1986	1st.	10/17 ~ 11/28 1/27/87 ~ 2/10/87	56	10%	12%
	2nd.	11/28 ~ 1/27/87	60	20%	22%
1994	1st.	8/22 ~ 9/3	12	10%	10%
	2nd.	9/3 ~ 9/10 9/27 ~ 9/29	9	15%	15%
	3rd.	9/10 ~ 9/16 9/19 ~ 9/27	14	20%	20%

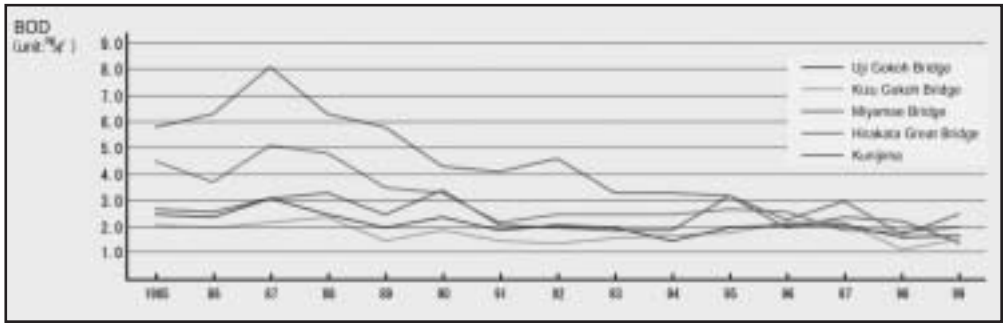
5.5 River Water Quality

River Water Quality[1)] at Hirakata-oohashi[2)] in 2000

Date	1/12	2/2	3/8	4/12	5/10	6/7	7/5	8/2	9/6	10/4	11/8	12/6
pH	7.5	7.4	7.4	7.5	7.8	7.6	7.5	7.7	7.7	7.4	7.4	7.4
BOD [mg/l]	1.6	1.8	1.4	1.4	1.7	0.8	1.2	0.9	1.5	0.9	0.9	0.9
COD_{Mn} [mg/l]	3.6	3.8	3.5	3.5	4	3.5	4.7	3.6	4.2	3.8	3.8	3.4
SS [mg/l]	7	10	11	7.8	4	7	25	4	6	7	7	5
Discharge[3)] [m^3/s]	101	107	132	136	127	200	218	156	116	145	145	122

1) Observed once a month on a dry day normally several days after rainfall.
2) Located near Osaka City 25 km upstream from the river mouth.
3) Discharge on the water quality observation date.

Present water quality of the Yodo River



6. Socio-cultural Characteristics

The Yodo River basin contains two large historical cities, Kyoto and Osaka. Kyoto played a central role in the development of Japan's history. The ancient capital was transferred from Nara to Kyoto in 794, which then became the centre of Japanese politics and culture for about 1,100 years until the transfer of the government to Tokyo in 1868. Osaka also fulfilled a vital role as a city of commerce, trade and diplomatic relations with Asian countries.

To support the development of the region, many river works have been conducted. The oldest flood control works in the area date back to the time of Emperor Nintoku (about 320 A.D.). Many flood control works have been performed since then, such as the separation of Ogura pond and the Uji River, the construction of the Bunrokutsutsumi (Bunroku Dike) by Hideyoshi Toyotomi in the 16th century, and the Yamato River redirection works during the first part of the 18th century. In the Meiji Period, western techniques were introduced to Japan by De Lekay, an engineer from Holland, Tadao Okino and others, which brought about the start of modern flood control water works and reformed the Yodo River into a new waterway.

Based on the historical development, this region constitutes the second largest economic bloc after the Tokyo Metropolitan area.

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