Water use and water balance in the lower reach of the Yellow River during the period of 1981-2000

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The lower reach of the Yellow River is defined as the zone from Huayuankou (about 100 m a.m.s.l.) to Lijin (about 12 m a.m.s.l.) with an administration area of about 4.43×10^4 km^2 and a population of about 2.5×10^7 (Ruan, 1997). This is an important agricultural area with an irrigation area of about 1.93×10^4 km^2 in 1990 by using the water diverted from the Yellow River (Xi, 1999; CDCID, 2002), accounting for about one-third of total irrigation area of the whole basin. Since much of sediment precipitates in the lower reach, raising the river bed, the Yellow River is higher than the riparian zone, i.e., the Yellow River is a suspended river in the lower reach and recharges the local aquifer along the river. Water table fluctuates due to precipitation and water diversion ranging from 1 to 4 m depth.

Water shortage is serious in the lower reach due to decreasing inflow at Huayuankou station and high demand for domestic, industrial and agricultural water use, especially in the North China Plain. The main objective of this study is to estimate water use and water balance in the lower reach during the period of 1981-2000.

Annual water use based on the flow difference between Lijin and Huayuankou station during the period of 1981-2000 was calculated with an average of 1.28×10^{10} m^3. It is relatively stable in this period compared with the water diverted before 1980, when there was an obvious increase trend since the early 1970's. Since discharge at Huayuankou decreases since the 1970s, the ratio of water diverted in the lower reach to the discharge at Huayuankou increases, and it is over 50% in the 1990s(Tab.1).

Tab.1 Water use calculated in the lower reach

Decade	1950s	1960s	1970s	1980s	1990s
(A) Water diverted, 10^8 m^3	42.3	31.3	88.9	136.7	121.9
(B) Observed discharge at Huayuankou, 10^8 m^3	458.7	521.8	372.8	420.2	236.9
Ratio= A/B, %	9.2	6.0	23.8	32.5	51.5

Water balance is evaluated primarily for precipitation, evaporation, groundwater table

change given as

$YW^{*}\beta = (AE - P + Dr \pm \triangle H)^{*}Ar$.....(1)

Where YW is the diverted water from the Yellow River, estimated as the flow difference; β is the irrigation coefficient; AE is the actual evapotranspiration (ET) with reference to the measurement by lysimeter in Yucheng Experimental Station of Chinese Academy of Science; P is precipitation; Dr is drainage; $\triangle H$ is water storage change in the soil and/or aquifer, which is generally negligible if monthly or yearly data is used; Ar is the irrigated area.

Since irrigation is basically carried out in April and May in the lower reach, ratio of water diversion to water deficit in the period, defined simply as the difference of precipitation and actual evaporation, shows a ratio of more than 1 before 1992 (Fig.1), i.e., extra water was diverted and drainage from the irrigation area was expected in this period. Since 1992, when drying up became serious in the lower reach, no sufficient water was guaranteed for irrigation, and almost there was no drainage or drained water was reused for irrigation before it reached the sea.

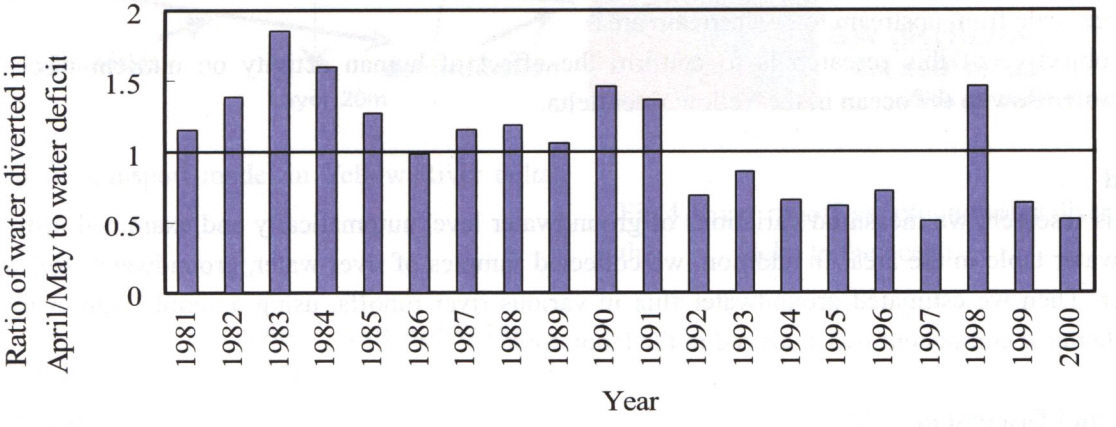

Fig.1 Ratio of water diverted to water deficit during the period of April and May in 1980-2000

Supposed a β value of 1 and a negligible value of Dr, calculation based on equation 1 results in an imbalance problem. Drainage, water loss from the water surface of channel/canal, used in the diversion of the Yellow River, and water diverted for domestic/industrial use could the factors associated with imbalance.