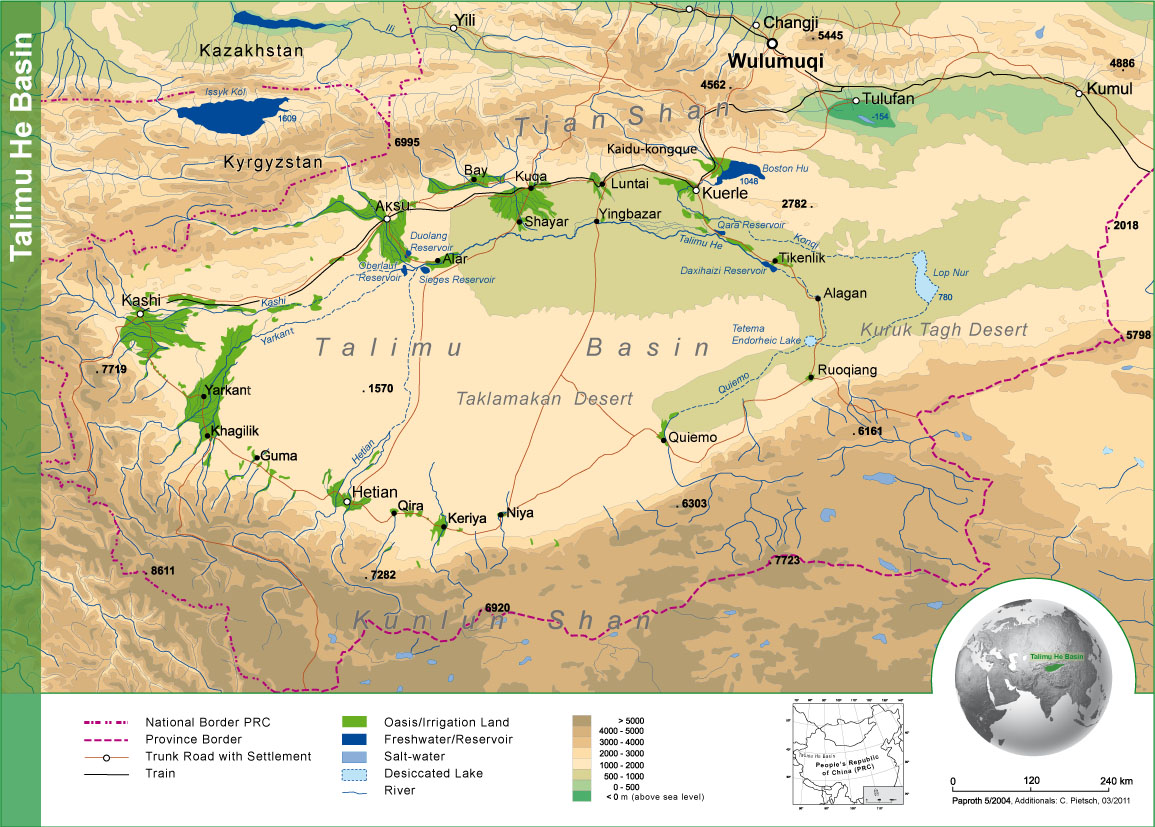
**CASE STUDY: Tarim River Basin, China**

*Prepared by Cindy Xin, University of Virginia*



**Figure 1: Tarim Basin**[[1]](#footnote-1)

**General Overview**

The 2,437 kilometer long (1500 mile long) Tarim River is the longest inland river in China. The watershed of the Tarim River is bounded by the high-altitude Tianshan, Kunlun, and Arjin mountain ranges (see figure below; the Tarim River is also called the “Talimu He” in China). Originally, the Tarim River was fed by nine tributaries, including the Kashgar River, Aksu River, Weigan River, Dinar River, Kaidu-kongque River, Cheerchen River, Keriya River, Hetian River, and Yarkant River. Due to the influence of both climate change and heavy use of water for agriculture in this watershed, the Cheerchen, Keriya, and Dina rivers dried up and became disconnected from the Tarim River before 1940, and since then three more rivers (Kashgar, Kaidu – kongque, and Weigan) have experienced similar fates and no longer contribute flow to the Tarim. Therefore, only the Aksu, Hetian, and Yarkant rivers still flow into the Tarim (Water from the Kaidu-kongque is occasionally pumped to the lower Tarim, but no longer flows naturally to the Tarim). (Source for this paragraph: Xinjiang Tarim River Basin Short-term Integrated Water Management Plan, 2001)

The area drained currently by Tarim River, Aksu River, Hetian River, Yarkant River and Kaidu-Kongque River (“four sources and one mainstream” area) is approximately 259,000 square kilometers (100,00 square miles), accounting for about 25% of the entire Tarim River watershed. The total runoff of the four source rivers is 2.57 billion m3 (2.1 million acre-feet), accounting for nearly two-thirds of the total runoff in the Tarim River watershed. China’s governmental water allocation programs are therefore focused mainly on these four tributaries. Administratively, the area of “four sources and one mainstream” is shared by 5 prefectures (the Bayangol, Aksu, Kizilsu, Kashgar and Hetian Prefecture) and four divisions of Xinjiang Production Construction Corps (XPCC). In 1998, the total population in the “four source rivers and one mainstream” area was 4.81 million. It is projected to increase to about 8.5 million by 2020. (Source of all the numbers in this paragraph: Xinjiang Tarim River Basin Short-term Integrated Water Management Plan, 2001)

**Water Budget**

The climate in the Tarim Basin is a typical continental desert climate with sparse precipitation, high evaporation, hot summers and cold winters. The Taklamakan desert (340 ×103 km), located in the center of the watershed, along with the eastern Gobi Desert which is located in the lower reaches of the Tarim River, both present an extremely arid climate. The average annual precipitation for the whole basin is 237 mm (9.3 inches), with the vast majority falling in the mountainous headwaters. In the center of the basin, precipitation ranges from only 50 to 70 mm (2-3 inches) per year, with some areas receiving less than 20 mm (<1 inch).

Evaporation in this area is very high. The evaporation rate in the mountainous area ranges from 800 to 1200 mm (31-47 inches) per year, while potential evaporation in the center of the watershed ranges from 2100 to 3000 mm (83-118 inches) per year. Essentially all rain in the low-lying areas of the watershed evaporates immediately, producing little to no runoff to rivers. A primary source of runoff is the thawing of glaciers and snow from the high mountains. Therefore, runoff in the watershed fluctuates greatly according to season. Most river runoff comes in the summer rain and snowmelt period from June to September, amounting to 60-80% of the annual total. The Tarim River thus experiences snowmelt-driven floods in the summer, but dries quickly during low-runoff periods.

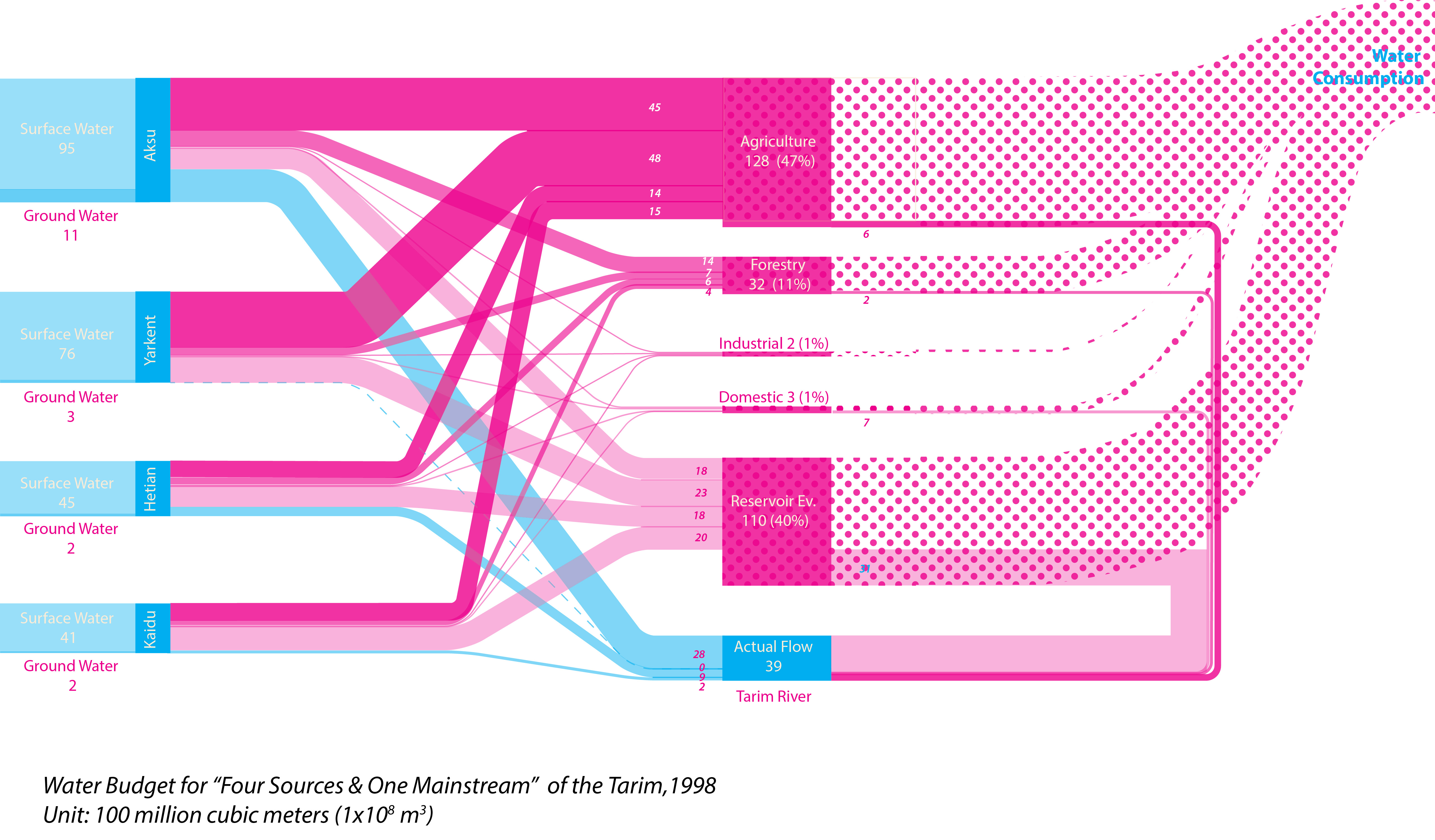
Due to extensive impoundment of water in storage reservoirs and many irrigation diversions, the water volume in the mainstream Tarim decreases quickly from upstream to downstream. The lower reach of the Tarim River has dried up during most years of the past century.

Table 1: **1998** Water Budget of the “Four Sources & One Mainstream” Area (unit: 100 million cubic meters). Data sources: please see “Water Budget Documentation”

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Category | Aksu | Yarkant | Hetian | Kaidu-Konque | Tarim Main-stream | "Four Sources & One Mainstream" | Percentage of Total |
| Precipitation | 55.48 | 40.69 | 24.64 | 22.13 |  | 142.94 | 52% |
| Snowmelt | 51.21 | 37.56 | 22.74 | 20.43 |  | 131.94 | 48% |
| Total Input | 106.69 | 78.25 | 47.38 | 42.56 | 38.70 | 274.88 | 100% |
| Surface water | 95.33 | 75.61 | 45.04 | 40.75 | 36.15 | 256.73 | 93% |
| Ground water | 11.36 | 2.64 | 2.34 | 1.81 | 2.55 | 18.15 | 7% |
| Total Input | 106.69 | 78.25 | 47.38 | 42.56 | 38.70 | 274.88 | 100% |
| Agricultural use | 45.27 | 48.03 | 14.19 | 15.16 | 5.64 | 128.29 | 46.7% |
| Forestry use | 13.88 | 6.65 | 5.94 | 4.12 | 1.53 | 32.12 | 11.7% |
| Industrial use | 0.72 | 0.39 | 0.13 | 0.35 | 0.00 | 1.58 | 0.6% |
| Domestic use | 0.67 | 0.83 | 1.16 | 0.53 | 0.09 | 3.28 | 1.2% |
| Total Human Use | 60.54 | 55.89 | 21.42 | 20.15 | 7.26 | 165.26 | 60% |
| Ecosystem use1 | 17.95 | 22.64 | 17.95 | 19.91 | 31.44 | 109.89 | 40% |
| Total Use | 78.49 | 78.53 | 39.37 | 40.06 | 38.70 | 275.15 | 100% |
| Outflow from basin | 28.20 | 0.00 | 8.00 | 2.50 | 0.00 | 0.00 |  |
| *1 Ecosystem use refers to natural losses of water in stream channels due to evaporation and transpiration by plants Ecosystem use* | | | | | | | |

Table 2: **2002** Water Budget of the “Four Sources & One Mainstream” Area (unit: 100 million cubic meters). Data sources: please see “Water Budget Documentation”

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Category | Aksu | Yarkant | Hetian | Kaidu-Konque | Tarim Main-stream | “Four Sources & One Mainstream” | Percentage of Total |
| Precipitation | 57.10 | 32.20 | 23.43 | 29.69 |  | 142.42 | 52% |
| Snowmelt | 52.70 | 29.72 | 21.63 | 27.41 |  | 131.46 | 48% |
| Total Input | 109.80 | 61.92 | 45.06 | 57.10 | 56.48 | 273.88 | 100% |
| Agricultural use | 47.04 | 53.48 | 18.94 | 32.71 | 6.30 | 158.46 | 58% |
| Forestry use | 14.42 | 7.40 | 7.93 | 8.88 | 1.71 | 40.34 | 15% |
| Industrial use | 0.75 | 0.43 | 0.17 | 0.75 | 0.00 | 2.10 | 1% |
| Domestic use | 0.70 | 0.92 | 1.55 | 1.14 | 0.10 | 4.41 | 2% |
| Total Human Use | 62.91 | 62.23 | 28.58 | 43.48 | 8.11 | 205.31 | 76% |
| Ecosystem use | 2.99 | 0.00 | 7.86 | 11.28 | 48.37 | 70.50 | 24% |
| Total Use | 65.90 | 62.23 | 36.44 | 54.76 | 56.48 | 275.81 | 100% |
| Outflow from basin | 43.90 | 0.00 | 8.58 | 2.34 | 0.00 | 0.00 |  |

Figure 2: Water budget for the Tarim’s “four sources & one mainstream” in 1998

**Temporal Variability in Water Availability**

When evaluating the potential for water shortages in the Tarim River watershed, it is important to note that inflows to the Tarim vary considerably from year to year. Note the differences in the “Total Water Input” for the Tarim River in Tables 1 & 2, and in the comparable volume of “Inflow to the Tarim River” in Table 3. Note from Tables 1 & 2 that due to very high natural losses of water in the stream channels due to evaporation and transpiration by plants, very little water is available for human uses from the Tarim River itself (note however that much more water use takes place in the four tributary rivers). During drier years, it is very difficult for water users to cut back on their water use, meaning that considerable competition can arise among water users, and much less water will remain flowing in the rivers.

Table 3: Multi-year average streamflow of the four sources and the mainstream (100 million cubic meters)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Year | River | Total Runoff Volume | Inflow to the Tarim River | Percent of runoff reaching the Tarim |
| 1950s | Aksu | 66.74 | 38.84 | 58.20% |
| Yarkant | 64.10 | 6.00 | 9.36% |
| Hetian | 47.17 | 13.13 | 27.84% |
| Kaidu-Kongque | 38.04 | 0.00 | 0.00% |
| Total | 216.00 | 59.30 | 27.45% |
| 1960s | Aksu | 79.34 | 42.48 | 53.54% |
| Yarkant | 64.16 | 2.41 | 3.76% |
| Hetian | 45.43 | 11.19 | 24.63% |
| Kaidu-Kongque | 32.59 | 0.00 | 0.00% |
| Total | 221.60 | 62.03 | 27.99% |
| 1970s | Aksu | 77.50 | 34.84 | 44.95% |
| Yarkant | 67.54 | 2.23 | 3.30% |
| Hetian | 47.44 | 11.82 | 24.92% |
| Kaidu-Kongque | 32.25 | 0.00 | 0.00% |
| Total | 225.80 | 51.91 | 22.99% |
| 1980s | Aksu | 78.35 | 35.16 | 44.88% |
| Yarkant | 64.07 | 0.31 | 0.48% |
| Hetian | 43.48 | 10.75 | 24.72% |
| Kaidu-Kongque | 30.92 | 1.48 | 4.79% |
| Total | 216.80 | 47.70 | 22.00% |
| 1990s | Aksu | 92.36 | 34.03 | 36.84% |
| Yarkant | 69.16 | 0.37 | 0.53% |
| Hetian | 42.77 | 8.65 | 20.22% |
| Kaidu-Kongque | 37.19 | 0.49 | 1.31% |
| Total | 241.90 | 43.54 | 18.00% |
| 2000-05 | Aksu | 100.00 | no information | no information |
| Yarkant | 80.80 | no information | no information |
| Hetian | 46.70 | no information | no information |
| Kaidu-Kongque | 52.80 | no information | no information |
| Subtotal | 280.30 | 48.6 | 17.34% |
| 2006-08 | Aksu | 78.70 | no information | no information |
| Yarkant | 87.20 | no information | no information |
| Hetian | 49.20 | no information | no information |
| Kaidu-Kongque | 39.10 |  |  |
| Subtotal | 254.20 | 38.9 | 15.30% |

Sources of data for Table 3:

*1950s – 1990s data source*: Xie F., Mao W., Zhang G., Gao Q., Shen Y., Wang J., Wang S. (2007). Analyze the Four Sources’ Discharge to the Mainstream of the Tarim in 2005 (塔里木河流域 2005 年四源流对干流供水径流情势分析). *Journal of Glaciology and Geocryology*, Vol. 29, No. 4. 2000 – 2008 data source: Yong, Hui. Study on Strategies and Influences of Agriculatural Development on Water Resource Use in the Tarim Basin (农业开发对塔里木河流域水资源利用影响及对策研究). (Doctoral dissertation). 2011. <http://cdmd.cnki.com.cn/Article/CDMD-10759-1011407232.htm>

**Water Toolbox**

**Desalination**

In November 2010, as government leaders considered energy goals for China’s upcoming 12th Five-Year Plan, a 60-year-old geographer named Huo Youguang suggested a proposal: drop a pipe into the Bohai Sea on China’s eastern shore, draw more than 340,000 cubic meters (90 million gallons) of seawater a day into a complex of coastal desalination plants, and then pump this water 1,400 meters uphill for more than 600 kilometers (nearly 400 miles) to Xilinhot, where it will be used for coal mining operations, with potential for extension westward into the Tarim watershed.[[2]](#footnote-2)

By the time Huo finished his presentation, he’d ignited a national engineering debate surrounding the cost, practicality and feasibility of using vast amounts of purified seawater to produce more coal for China’s modernisation, while simultaneously easing northern China’s water shortage. By suggesting a giant project that some authorities considered daffy, Huo also confirmed just how vulnerable China’s powerful engine of growth is to deepening water scarcity, particularly in the energy-rich northern and western provinces, now the primary focus of China’s development and modernisation.

Huo had first proposed an across-the-north route for a pipeline from the Bohai Sea back in 1997. In 2002, a separate academic team from Peking University proposed a similar route, but further to the north. However, both pipelines—which would transport water more than 3,400 kilometers (2,100 miles) to Xinjiang in the heart of the Tarim watershed —are seen by a number of Chinese engineers as impractical for various engineering, environmental and economic reasons.



Figure 5: China’s water/coal relationship [[3]](#footnote-3)

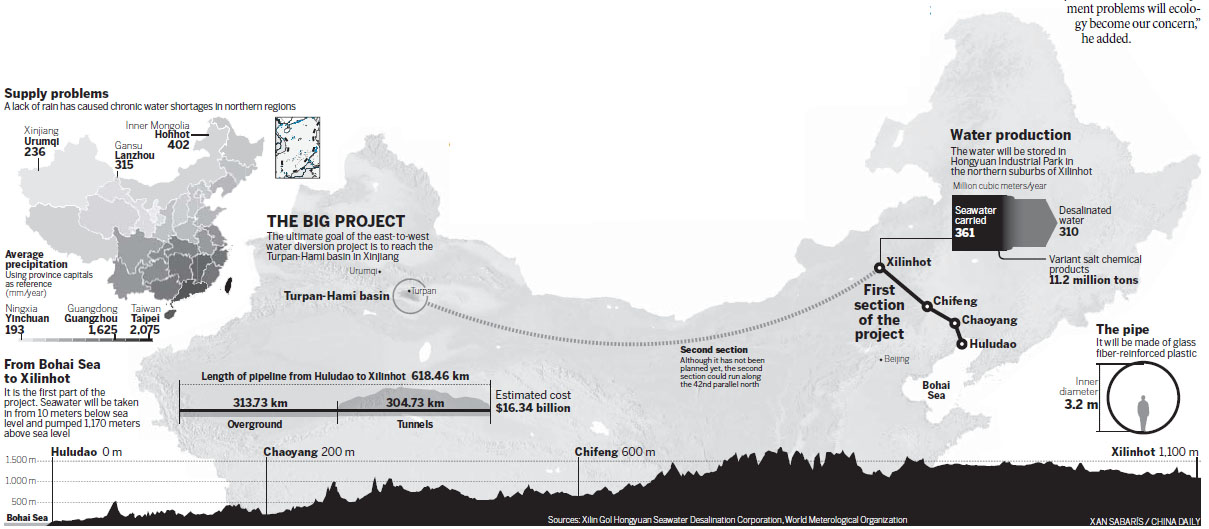


Figure 6: Conceptual map of the Bohai Sea pipeline project [[4]](#footnote-4)

**Water Storage**

Agricultural development in the Tarim watershed heavily relies on irrigation. Because of the temporal and spatial imbalance of runoff volume, water storage projects are widely utilized in the watershed. Currently, there are totally 286 irrigation diversion canals located on the mainstream of the Tarim and its four source rivers. Their total designed water delivery capacity is 882 m3/s, while the current actual capacity is 765 m3/s. Their total designed irrigation area is 22505 km2, but their actual effective irrigation area is 14181 km2.

Table 4 Irrigation diversions within the “four sources and one mainstream” area of the Tarim[[5]](#footnote-5)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sub-watershed | Number of diversions | Designed irrigated area/km2 | Actual irrigated area/km2 | Designed water supply ability m3/s | Actual water supply capacity m3/s |
| Aksu | 63 | 7020 | 5700 | 198.6 | 165.5 |
| Hetian | 27 | 629 | 484 | 81.4 | 62.60 |
| Yarkant | 26 | 12220 | 3293 | 220.3 | 169.5 |
| Kaidu-Konque | 32 | 2449 | 2013 | 89.12 | 74.26 |
| Tarim mainstream | 138 | 854 | 799 | 293 | 293 |
| Total | 286 | 22505 | 14181 | 882.42 | 764.86 |

There are 76 reservoirs in the “four sources and one mainstream” area, with a total water storage capacity of 280 million cubic meters. The designed irrigated area for all the reservoirs together is supposed to be 5116 km2, whereas its effective area is 3654 km2 , accounting for 24% of the total irrigated area in the basin.

Table 5 Reservoirs within the “four sources and one mainstream” area of the Tarim[[6]](#footnote-6)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| River | Number of reservoirs | Total capacity (units: 100 million cubic meters) | Designed Irrigated Area (km2) | Actual Irrigated Area (km2) |
| Hetian | 20 | 0.235 | 363 | 333 |
| Asku | 6 | 0.49 | 1051 | 809 |
| Yarkant | 37 | 1.42 | 3038 | 2013 |
| Kaidu-Konque | 5 | 0.077 | 0 | 0 |
| Tarim mainstream | 8 | 0.586 | 663 | 450 |
| Total | 76 | 2.808 | 5116 | 3554 |

**Water Importation**

See desalination section above for information about a proposed water importation project from the Bohai Sea to the Tarim watershed.

While not technically a “water importation project” (which implies moving water from one watershed to another), water is being transferred via pipelines and canals from Bosten Lake, a reservoir in the headwaters of the Kaidu River, to Daxihaizi Reservoir in the lower reaches of the Tarim, where water is released into the lower river in order to restore the river ecosystem.[[7]](#footnote-7) This project started in 2000 and is called the “Ecological Water Transfer Project.”

As of January 2011, this project has been carried out eleven times, and in the cases of eight times, water has reached the Taitema Lake, at the terminus of the lower river. A total volume of 52-298 million cubic meters have been released from Daxihaizi Reservoir during each of these restoration events. It has been observable that the vegetation recovered and wildlife returned,[[8]](#footnote-8) after enduring more than two decades of complete river drying.

Figure (left): dried river bed before importing water. Figure (right): recovered river bed after importing water[[9]](#footnote-9).

**Watershed Management (Water Allocation)**

A system of water allocations has been developed to manage water use in the Tarim watershed, involving detailed water quotas for the sources and the mainstream, as seen in the table below. The water quota system consists of three levels: (i) between source streams (the Aksu, Yerkant, Hotan River) and the Tarim mainstream; (ii) between environmental use and human use; (iii) between agricultural, forestry, industrial and domestic users.

Table 6: 2005 water quota plan of the “four sources and one mainstream” of the Tarim[[10]](#footnote-10)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Aksu | Yarkant | Hetian | Kaidu | Tarim | Four Sources & one mainstream | Percentage of Total |
| Precipitation | 51.92 | 37.85 | 22.20 | 20.06 | 26.52 | 132.03 | 52% |
| Snowmelt | 47.93 | 34.94 | 20.50 | 18.51 | 24.48 | 121.88 | 48% |
| Total Water Input | 99.85 | 72.79 | 42.70 | 38.57 | 51.00 | 253.91 | 100% |
| Agricultural use | 36.60 | 38.68 | 10.93 | 14.50 | 6.26 | 106.97 | 42.1% |
| Forestry use | 11.22 | 5.35 | 4.57 | 3.94 | 1.70 | 26.79 | 10.55% |
| Industrial use | 0.58 | 0.31 | 0.10 | 0.33 | 0.00 | 1.32 | 1% |
| Domestic use | 0.55 | 0.67 | 0.89 | 0.51 | 0.10 | 2.71 | 1% |
| Total Human Use | 48.95 | 45.01 | 16.50 | 19.27 | 8.06 | 137.79 | 55% |
| Ecosystem use | 16.70 | 24.70 | 17.20 | 14.80 | 39.44 | 112.84 | 45% |
| Total Use | 65.65 | 69.71 | 33.70 | 34.07 | 47.50 | 250.63 | 100% |
| Outflow from basin | 34.20 | 3.30 | 9.00 | 4.50 | 3.50 | 3.50 | <1% |

**Water Conservation**

Several measures have been underway for saving water in the Tarim River watershed. Drip irrigation for agriculture has been widely applied in this region, particularly in the lower reaches of the watershed. In order to use water efficiently and save water for the ecosystem, a policy was issued stating that farmlands located far away from water sources should not be cultivated, to allow water to be conserved for natural ecosystems. This project, called Return Farmland to Forest/Grassland, is a national policy implemented in ecological fragile areas across the country. In some cases, local famers and herders have had to leave their farms and move to collective settlement areas arranged by local governments. This is called Ecological Migration. A compensation for abandoned farmland is given to the farmers.

**Water Reuse**

Water reuse has not been implemented in this basin.

**Water Stakeholders**

Confronted with serious water resources crisis, various actions have been taken by the central government and the state government since the late 1990s to set up a unified water management authority and make a comprehensive watershed management plan for the Tarim River watershed. Meanwhile, a lot of civil society organizations have devoted their time, energy and wisdom to the future planning of the watershed. An official water distribution program, which distinguishes water use for production, livelihood and ecology, has been analyzed thoroughly and justified within the framework of sustainability.

While the concept of sustainability has been applied at the decision-making level, it has not been adequately implemented in practical water distribution. Water distribution among different areas is based on the water quota system. Contracts are signed each year between the state government and representatives of all related prefectures as well as divisions of Xinjiang Production and Construction Corps. Though all relevant institutions agree to unified water management and the necessity of institutional reform, in practice, the implementation of the water quota system is facing various barriers due to lack of public participation (especially farmers) in the early stages, incomplete water laws, and weak legal enforcement.

**Farmers:** Irrigated agriculture takes the biggest part of water use in the Tarim watershed. Nearly 80% of the people in the watershed derive their income directly or indirectly from agriculture. In a large area along the middle and lower reaches of the Tarim River, pasture grassland is also dependent on irrigation and most indigenous people, the Uyghur, depend upon animal herding. Thus, people living from farming and animal herding, who are usually the lowest income groups, are also the biggest group influenced by water distribution. First, a farmer’s income depends directly on whether water is distributed justly or not. Second, in order to implement those projects in compliance with the water distribution program, such as the Return Farmland to Forest/Grassland project, some farmers and herds have to give up their lands or leave their homes. Third, farmers cannot afford investments in water-saving techniques and are not willing to pay a water price that reflects the value of water.

**Oil-exploitation Industry**: The amount of water allocated to oil exploitation is given high priority over the whole range of runoff in the Tarim River. Furthermore, the oil-exploiting industry has sufficient equipment and capital at its disposal to exploit groundwater as needed. The oil industry even has the capability of pumping so much groundwater that the groundwater level drops too deep for the farmers to access.

**Local Government**: Local governments frequently complain that they have no power to deal with affairs in their own administration areas. Managers with expertise cannot decide on their own affairs. “A problem also occurs when a certain state department leader who has expertise on a certain field has to submit himself to the leader of the national government who knows nothing about the field”. The Wildlife Protection and Management Department of Bayangol, which is an autonomous prefecture of Xinjiang Province, failed to stop land reclamation in natural forests. They said that “the permission of land reclamation is not given by forest administrations, but by government of much higher level. It is not what we can manage and control as low-level administrators.”

**Environmental conservationists**: As highlighted earlier, restoration of the riparian forest along the lower Tarim River is of great interest, but it requires a reduction of water allocation to agriculture.

**Water Budget Documentation**

Table: 1998 water budget of the “four sources and one mainstream” of the Tarim

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Category | **Aksu** | **Yarkant** | **Hetian** | **Kaidu** | **Tarim Mainstream** | **"Four Sources & One Mainstream"** |
| Year | **1998** | **1998** | **1998** | **1998** | **1998** | **1998** |
| Precipitation | 55.48 | 40.69 | 24.64 | 22.13 |  | 142.94 |
| Snowmelt | 51.21 | 37.56 | 22.74 | 20.43 |  | 131.94 |
| *Total Water Resources* | *106.69* | *78.25* | *47.38* | *42.56* | *38.70* | *274.88* |
| Surface water | 95.33 | 75.61 | 45.04 | 40.75 | 36.15 | 256.73 |
| Ground water | 11.36 | 2.64 | 2.34 | 1.81 | 2.55 | 18.15 |
| *Total Input* | *106.69* | *78.25* | *47.38* | *42.56* | *38.70* | *274.88* |
| Agricultural use | 45.27 | 48.03 | 14.19 | 15.16 | 5.64 | 128.29 |
| Forestry use | 13.88 | 6.65 | 5.94 | 4.12 | 1.53 | 32.12 |
| Industrial use | 0.72 | 0.39 | 0.13 | 0.35 | 0.00 | 1.58 |
| Domestic use | 0.67 | 0.83 | 1.16 | 0.53 | 0.09 | 3.28 |
| *Total Human Use* | *60.54* | *55.89* | *21.42* | *20.15* | *7.26* | *165.26* |
| Ecosystem use | **17.95** | **22.64** | **17.95** | **19.91** | 31.44 | 109.89 |
| *Total Use* | *78.49* | *78.53* | *39.37* | *40.06* | *38.70* | *275.15* |
| Total Output | *28.20* | *0.00* | *8.00* | *2.50* | *0.00* | *0.00* |

1. Numbers in red means they are derived from reliable report or papers directly. Numbers in purple means they are calculated with certain average proportion data. Number in black are gotten through calculating numbers in red and purple.

1. Total water resource data is derived from: Xinjiang Uygur Autonomous Region People's Government, National Ministry of Water Resources. Tarim Basim Recent Comprehensive Management Plan (塔里木河流域近期综合治理规划). 2001. <https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=4&ved=0CEkQFjAD&url=http%3A%2F%2F218.31.134.254%3A81%2Fshlj%2FUploadFiles_6503%2F200707%2F20070705135129577.doc&ei=Y_lLU5fxCpLE0AGQs4CgCA&usg=AFQjCNFUJGoY2TP4KvwfB9zjQx46ghRyNg&sig2=3rh-9EOiEy1nKRJu1jvdYQ&bvm=bv.64542518,d.dmQ&cad=rjt>
2. According to the 2001 Tarim Basim Recent Comprehensive Management Plan, it is known that how many percent input water in the whole basin was from precipitation (52%) and how many percent was from snowmelt (48%). It is assumed that Aksu, Yankant, Hetian, and Kaidu have the same precipitation-snowmelt ratio. In Aksu river, for example, the water coming from precipitation equates to total water resources multiplied by 52%.
3. Surface water and ground water data is derived from 2001 Tarim Basim Recent Comprehensive Management Plan.
4. In this case, the total output of the Aksu, Yarkant, Hetian, and refers to the amount of water discharging to the Tarim mainstream. They are derived from 2001 Tarim Basim Recent Comprehensive Management Plan. The output of the Tarim mainstream refers to the amount of water discharging to Daxihaizi reservoir.
5. The percent of water consumed by ecosystem is derived from: Deng, Mingjiang. A Preliminary Study on Water Right Management in the Tarim River Basin Comprehensive Management. China Water Resources. 2003, 3(1). <http://d.wanfangdata.com.cn/Periodical_zhonggsl200301014.aspx>. Accordingly, the ecosystem water use is gotten by multiplied the percentage with the total water resources.
6. According to Hui Yong’s doctoral dissertation, it is known that how much water each sector consume respectively from 2001 to 2005. With these statistics, I calculated the average proportion of water consumed by each sector. Then the amount of water consumed by each sector = (total water – total output – ecosystem use) \* percent. The table below is derived from: Yong, Hui. Study on Strategies and Influences of Agriculatural Development on Water Resource Use in the Tarim Basin (农业开发对塔里木河流域水资源利用影响及对策研究). (Doctoral dissertation). 2011. <http://cdmd.cnki.com.cn/Article/CDMD-10759-1011407232.htm>

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Year** | **Subbasin** | **Agriculture** | | **Forestry** | | **Industry** | | **Domestric** | | **Total** |
|  |  | **Subtotal** | **%** | **Subtotal** | **%** | **Subtotal** | **%** | **Subtotal** | **%** | **Total** |
| **2001** | **Hetian** | 18.49 | 72% | 6.46 | 25% | 0.22 | 1% | 0.37 | 1% | 25.55 |
| **Yarkant** | 44.19 | 92% | 3.63 | 8% | 0.10 | 0% | 0.17 | 0% | 48.09 |
| **Aksu** | 26.39 | 75% | 7.53 | 21% | 0.68 | 2% | 0.46 | 1% | 35.06 |
| **Kai-kong** | 12.40 | 73% | 3.55 | 21% | 0.64 | 4% | 0.49 | 3% | 17.08 |
| **Tarim** | 14.37 | 78% | 4.09 | 22% | 0.00 | 0% | 0.03 | 0% | 18.50 |
| **Subtotal** | 115.84 | 80% | 25.27 | 18% | 1.63 | 1% | 1.53 | 1% | 144.27 |
| **2002** | **Hetian** | 17.30 | 64% | 9.15 | 34% | 0.13 | 0% | 0.35 | 1% | 26.94 |
| **Yarkant** | 53.28 | 87% | 7.13 | 12% | 1.60 | 3% | 0.60 | 1% | 61.17 |
| **Aksu** | 47.97 | 79% | 11.36 | 19% | 0.73 | 1% | 0.55 | 1% | 60.60 |
| **Kai-kong** | 29.25 | 71% | 10.22 | 25% | 0.83 | 2% | 0.90 | 2% | 41.21 |
| **Tarim** | 4.28 | 53% | 3.81 | 47% | 0.00 | 0% | 0.03 | 0% | 8.11 |
| **Subtotal** | 152.09 | 77% | 41.67 | 21% | 1.84 | 1% | 2.43 | 1% | 198.03 |
| **2003** | **Hetian** | 13.69 | 60% | 6.44 | 28% | 0.10 | 0% | 2.44 | 11% | 22.68 |
| **Yarkant** | 57.03 | 87% | 8.19 | 12% | 0.13 | 0% | 0.32 | 0% | 65.67 |
| **Aksu** | 43.84 | 78% | 11.78 | 21% | 0.19 | 0% | 0.43 | 1% | 56.24 |
| **Kai-kong** | 29.75 | 77% | 7.66 | 20% | 0.74 | 2% | 0.48 | 1% | 38.62 |
| **Tarim** | 10.22 | 86% | 1.57 | 13% | 0.01 | 0% | 0.06 | 1% | 11.85 |
| **Subtotal** | 154.53 | 79% | 35.62 | 18% | 1.18 | 1% | 3.72 | 2% | 195.05 |
| **2004** | **Hetian** | 16.55 | 67% | 5.89 | 24% | 0.12 | 0% | 2.07 | 8% | 24.63 |
| **Yarkant** | 48.37 | 81% | 9.99 | 17% | 0.13 | 0% | 1.59 | 3% | 60.07 |
| **Aksu** | 37.47 | 70% | 15.00 | 28% | 0.21 | 0% | 0.72 | 1% | 53.39 |
| **Kai-kong** | 25.15 | 78% | 5.60 | 17% | 0.30 | 1% | 1.14 | 4% | 32.18 |
| **Tarim** | 9.19 | 89% | 1.09 | 11% | 0.00 | 0% | 0.08 | 1% | 10.36 |
| **Subtotal** | 136.72 | 76% | 37.57 | 21% | 0.76 | 0% | 5.59 | 3% | 180.64 |
| **2005** | **Hetian** | 16.32 | 67% | 6.53 | 27% | 0.16 | 1% | 1.51 | 6% | 24.52 |
| **Yarkant** | 51.55 | 87% | 6.27 | 11% | 0.08 | 0% | 1.70 | 3% | 59.59 |
| **Aksu** | 38.17 | 71% | 13.75 | 25% | 1.28 | 2% | 0.73 | 1% | 53.94 |
| **Kai-kong** | 22.24 | 77% | 5.23 | 18% | 0.21 | 1% | 1.14 | 4% | 28.83 |
| **Tarim** | 7.36 | 76% | 1.80 | 19% | 0.00 | 0% | 0.51 | 5% | 9.67 |
| **Subtotal** | 135.65 | 77% | 33.58 | 19% | 1.73 | 1% | 5.59 | 3% | 176.55 |
| **01- 05** | **Hetian** |  | 66% |  | 28% |  | 1% |  | 5% |  |
| **Yarkant** |  | 86% |  | 12% |  | 1% |  | 1% |  |
| **Aksu** |  | 75% |  | 23% |  | 1% |  | 1% |  |
| **Kai-kong** |  | 75% |  | 20% |  | 2% |  | 3% |  |
| **Tarim** |  | 78% |  | 21% |  | 0% |  | 1% |  |
| **Subtotal** |  | 78% |  | 19% |  | 1% |  | 2% |  |

Table 2: **2002** Water Budget of the “Four Sources & One Mainstream” Area (unit: 100 million cubic meters).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Water Use in the Tarim Basin** | | |  |  |  |  |
| Category | **Aksu** | **Yarkant** | **Hetian** | **Kaidu** | **Tarim** | **Four Sources and one stream** |
| Year | **2002** | **2002** | **2002** | **2002** | **2002** | **2002** |
| Precipitation | 57.10 | 32.20 | 23.43 | 29.69 | 29.37 | 142.42 |
| Meltwater | 52.70 | 29.72 | 21.63 | 27.41 | 27.11 | 131.46 |
| *Total Water Resources* | *109.80* | *61.92* | *45.06* | *57.10* | *56.48* | *273.88* |
| Surface water |  |  |  |  |  |  |
| Ground water |  |  |  |  |  |  |
| *Total Input* | *109.8* | *61.92* | *45.06* | *57.10* | *56.48* | *273.88* |
| Agricultural use | 47.04 | 53.48 | 18.94 | 32.71 | 6.30 | 158.46 |
| Forestry use | 14.42 | 7.40 | 7.93 | 8.88 | 1.71 | 40.34 |
| Industrial use | 0.75 | 0.43 | 0.17 | 0.75 | 0.00 | 2.10 |
| Domestic use | 0.70 | 0.92 | 1.55 | 1.14 | 0.10 | 4.41 |
| *Total Human Use* | *62.91* | *62.23* | *28.58* | *43.48* | *8.11* | *205.31* |
| Ecosystem use | 2.99 | 0.00 | 7.86 | 11.28 | 48.37 | 70.50 |
| *Total Use* | *65.90* | *62.23* | *36.44* | *54.76* | *56.48* | *275.81* |
| Total Output | *43.90* | *0.00* | *8.58* | *2.34* | *0.00* | *0.00* |

1. Numbers in red means they are derived from reliable report or papers directly. Numbers in purple means they are calculated with certain average proportion data. Number in black are gotten through calculating numbers in red and purple.

1. Total water resource data is derived from: Wang, Deshun et al. Water Consumption Analysis of the Tarim River's Four Headstreams (2002年塔里木河流域四条源流区间耗水分析). Journal of Glaciology and Geocryology. 2004, 26(4): 496-502. <http://bcdt.westgis.ac.cn/fileup/PDF/20040418.pdf>
2. According to the 2001 Tarim Basim Recent Comprehensive Management Plan, it is known that how many percent input water in the whole basin was from precipitation (52%) and how many percent was from snowmelt (48%). It is assumed that Aksu, Yankant, Hetian, and Kaidu have the same precipitation-snowmelt ratio. In Aksu river, for example, the water coming from precipitation equates to total water resources multiplied by 52%.
3. Surface water and ground water data is unknown.
4. In this case, the total output of the Aksu, Yarkant, Hetian, and refers to the amount of water discharging to the Tarim mainstream. They are derived from 2001 Tarim Basim Recent Comprehensive Management Plan. The output of the Tarim mainstream refers to the amount of water discharging to Daxihaizi reservoir.
5. The percent of water consumed by ecosystem is derived from: Deng, Mingjiang. A Preliminary Study on Water Right Management in the Tarim River Basin Comprehensive Management. China Water Resources. 2003, 3(1). <http://d.wanfangdata.com.cn/Periodical_zhonggsl200301014.aspx>. Accordingly, the ecosystem water use is gotten by multiplied the percentage with the total water resources.
6. According to Hui Yong’s doctoral dissertation, it is known that how much water each sector consume respectively from 2001 to 2005. With these statistics, I calculated the average proportion of water consumed by each sector. Then the amount of water consumed by each sector = (total water – total output – ecosystem use) \* percent. The table below is derived from: Yong, Hui. Study on Strategies and Influences of Agriculatural Development on Water Resource Use in the Tarim Basin (农业开发对塔里木河流域水资源利用影响及对策研究). (Doctoral dissertation). 2011. <http://cdmd.cnki.com.cn/Article/CDMD-10759-1011407232.htm>

1. Source: http://www.sumario.de/ [↑](#footnote-ref-1)
2. News source: https://www.chinadialogue.net/article/show/single/en/4332-Pipeline-pressures-in-north-China [↑](#footnote-ref-2)
3. Source: Circle of Blue. 2011. http://www.circleofblue.org/waternews/2011/world/desalinating-the-bohai-sea-transcontinental-pipeline-could-open-chinas-northern-coal-fields/ [↑](#footnote-ref-3)
4. Source: China Daily. 2010. http://www.chinadaily.com.cn/china/2010-11/29/content\_11620772\_2.htm [↑](#footnote-ref-4)
5. Source: Yong, Hui. Study on Strategies and Influences of Agriculatural Development on Water Resource Use in the Tarim Basin (农业开发对塔里木河流域水资源利用影响及对策研究). (Doctoral dissertation). 2011. http://cdmd.cnki.com.cn/Article/CDMD-10759-1011407232.htm [↑](#footnote-ref-5)
6. Source: Yong, Hui. Study on Strategies and Influences of Agriculatural Development on Water Resource Use in the Tarim Basin (农业开发对塔里木河流域水资源利用影响及对策研究). (Doctoral dissertation). 2011. http://cdmd.cnki.com.cn/Article/CDMD-10759-1011407232.htm [↑](#footnote-ref-6)
7. Li, Y., Y. Chen, Y. Zhang, and Y. Xia. 2009. Rehabilitating China’s largest inland river. *Conservation Biology* 23: 531-536. [↑](#footnote-ref-7)
8. http://tahe.gov.cn/e/action/ShowInfo.php?classid=65&id=12690 [↑](#footnote-ref-8)
9. Source: http://tahe.gov.cn/e/action/ShowInfo.php?classid=65&id=12690 [↑](#footnote-ref-9)
10. Source: Deng, Mingjiang. A Preliminary Study on Water Right Management in the Tarim River Basin Comprehensive Management. China Water Resources. 2003, 3(1). http://d.wanfangdata.com.cn/Periodical\_zhonggsl200301014.aspx [↑](#footnote-ref-10)