

# 5 Amu Darya Basin

The Amu Darya river originates in Tajikistan and Kyrgyzstan in two headstreams, the Panj and Vakhsh rivers. The river flows west-northwest into the Aral Sea and is one of the longest rivers in Central Asia: 2,540 km measured from the remotest sources of the Panj river. The catchment area is about 645,726 km<sup>2</sup>. The Amu Darya river forms a part of Afghanistan's border with Tajikistan, Uzbekistan, and Turkmenistan, and a part of Uzbekistan's border with Turkmenistan. The part of the Amu Darya river basin within the HKH region lies entirely within Afghanistan, covering an area of about 166,686 km<sup>2</sup>, a quarter of the total basin area.

## Data

The mapping and inventory of the glaciated areas in the sub-basins of the Amu Darya basin within the territory of Afghanistan was carried out using ETM+ images from 2005 and 2006. The topographic characteristics were derived using the SRTM DEM. The list of images used is shown in Table 5.1.

## Mapping and Inventory of Glaciers

The part of the Amu Darya river basin within Afghanistan consists of three major sub-basins: the Wakhan, Kokcha, and Surkhab (Figure 5.1). The glaciers are distributed between 34.58° and 38.35° N latitude and 67.63° and 74.88° E longitude, with the highest concentration between 36.45° and 38.35° N latitude and 70.65° and 74.88° E longitude in the Wakhan sub-basin. The distribution and characteristics of the glaciers in each sub-basin are summarised in Table 5.2.

## Number, area, and ice reserves

The Amu Darya basin had 3,277 glaciers (2,047 in the Wakhan sub-basin, 913 in the Kokcha sub-basin, and 317 in the Surkhab sub-basin) with a total area of 2,566 km<sup>2</sup> and estimated ice reserves of 163 km<sup>3</sup> (Table 5.2 and Figure 5.2).

The Wakhan is the third largest sub-basin in Afghanistan but the most glaciated, with 76% of the total glaciated area, the largest number of CI and DC glaciers, the largest ice reserves (82% of the total), the longest glacier, the largest glacier, and the glacier with the greatest elevation difference.

## Glacier area classes

The number, area, and estimated ice reserves of glaciers in the different size classes are summarised in Table 5.3 and shown as a percentage of the total in Figure 5.3. The area per glacier in the different sub-basins ranged from 0.35 km<sup>2</sup> to 0.95 km<sup>2</sup>, with an average of 0.78 km<sup>2</sup> overall (Table 5.2). The majority of glaciers (67%) were in the smallest class 1 ( $\leq 0.5$  km<sup>2</sup>), and contributed 16% of the glacier area and 6% of the ice reserves. These small

**Table 5.1: Landsat images used for the Amu Darya basin**

Path-Row	Image	Date	Used for	Sub-basin
150-34	LE71500342005259PFS00	16/09/2005	correction	Wakhan
151-34	LE71510342005234PFS00	22/08/2005	correction	Wakhan
152-33	LE71520332006212ASN00	31/07/2006	analysis	Wakhan
152-34	LE71520342006212ASN00	31/07/2006	analysis	Wakhan, Kokcha, Surkhab
152-35	LE71520352006260PFS01	17/09/2006	analysis	Kokcha

Figure 5.1: Distribution of glaciers in the Amu Darya basin

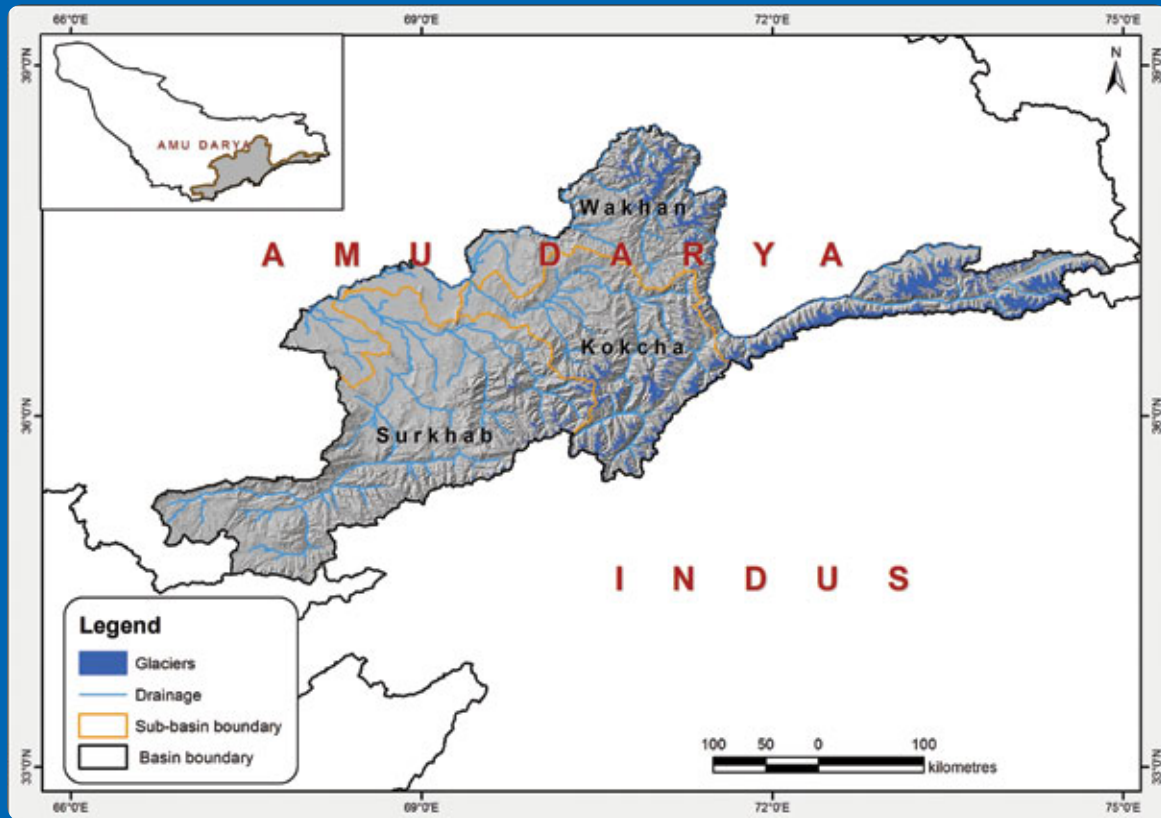


Table 5.2: Glacier characteristics in the sub-basins of the Amu Darya basin within the HKH region

Parameter	Unit	Sub-basin			Amu Darya
		Wakhan	Kokcha	Surkhab	
Basin area	km <sup>2</sup>	27,173	21,338	37,913	166,686*
Latitude	degrees	36.45-38.35	35.45-37.22	34.56-36.48	34.58-38.35
Longitude	degrees	70.65-74.88	70.11-71.63	67.63-70.49	67.63-74.88
Number of glaciers	unit	2,047	913	317	3,277
CI glacier area	km <sup>2</sup>	1,878.48	430.11	97.00	2,405.59
DC glacier area	km <sup>2</sup>	72.57	72.99	15.03	160.59
Total glacier area	km <sup>2</sup>	1,951.05	503.10	112.03	2,566.18
Largest glacier area	km <sup>2</sup>	39.72	9.36	9.82	39.72
Total ice reserves	km <sup>3</sup>	133.56	24.27	4.48	162.61
Highest elevation	masl	7,213	6,790	5639	7,213
Lowest elevation	masl	3,131	3,616	3,621	3,131
CI glacier elevation	masl	3,415-7,213	3,990-6,790	3,888-5,639	3,415-7,213
DC glacier elevation	masl	3,131-5,425	3,616-5,466	3,621-4,998	3,131-5,466
Mean CI glacier slope	degrees	24	26	24	25
Mean DC glacier slope	degrees	10	13	12	11
CI-DC area ratio	unit	25.89	5.89	6.46	14.98
Average glacier area	km <sup>2</sup>	0.95	0.55	0.35	0.78

\*Area including not glaciated sub-basins

**Table 5.3: Glacier area classes in the Amu Darya basin within the HKH region**

Area class	Area (km <sup>2</sup> )	Number		Area		Estimated ice reserves		Mean area per glacier
		Total	%	km <sup>2</sup>	%	km <sup>3</sup>	%	km <sup>2</sup>
1	≤ 0.5	2,203	67.2	415.31	16.2	9.807	6.0	0.19
2	0.51-1.00	523	16.0	371.42	14.5	13.764	8.5	0.71
3	1.01-5.00	474	14.5	969.78	37.8	55.612	34.2	2.05
4	5.01-10.00	50	1.5	345.06	13.5	29.092	17.9	6.90
5	≥10.00	27	0.8	464.62	18.1	54.334	33.4	17.21
<b>Total</b>		<b>3,277</b>	<b>100</b>	<b>2,566.18</b>	<b>100</b>	<b>162.609</b>	<b>100</b>	<b>0.78</b>

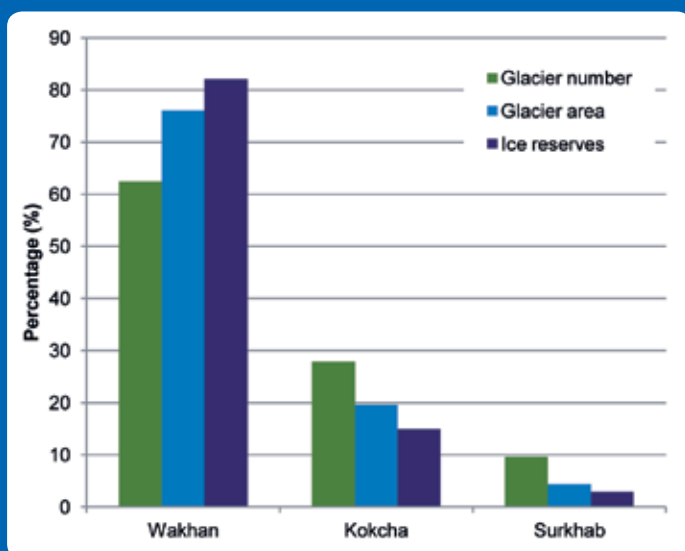
glaciers are very sensitive to changes in climate. Glaciers in class 3 (1.0 to 5.0 km<sup>2</sup>) were third highest in number but had the greatest area (38% of the total) and estimated ice reserves (34% of the total). The large glaciers in class 5 (≥10.0 km<sup>2</sup>) had an average area of 17.21 km<sup>2</sup> and contributed about 18% of the glacier area and 33% of the ice reserves.

The largest glacier was GLIMS ID G072586E36890N (Awagr10\_1022), located in the Wakhan sub-basin (36.89° N latitude and 72.59° E longitude). It had an area of 39.72 km<sup>2</sup> and estimated ice reserves of 5.93 km<sup>3</sup>, and extended from 6,293 masl to 3,131 masl, the lowest terminus in Afghanistan. The highest elevation glacier was GLIMS ID G071765E36445N (Awagr10\_1198), with a crown at 7,213 masl, glacier area of 17.40 km<sup>2</sup>, and estimated ice reserves of 1.98 km<sup>3</sup>.

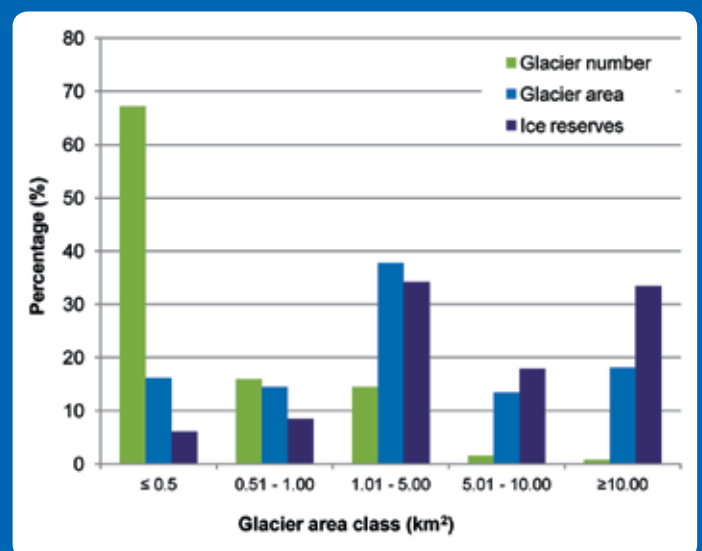
### Glacier elevation

The elevation of Afghanistan’s land area ranges from 7,485 masl at the peak of Noshak mountain to 258 masl in the Amu Darya river valley. The highest glacier elevation was 7,213 masl and the lowest 3,131 masl, both in the Wakhan sub-basin. The extended elevation range in the Wakhan sub-basin reflects the presence of valley type glaciers. CI glaciers were found from 7,213 to 3,415 masl and DC glaciers from 5,466 to 3,131 masl (Figure 5.4). The lower extension of DC glaciers indicates the presence of basin type glaciers.

**Figure 5.2: Glacier number, area, and estimated ice reserves in the sub-basins of the Amu Darya basin**



**Figure 5.3: Percentage of glacier number, area, and estimated ice reserves in the different glacier size classes in the Amu Darya basin**



## Glacier aspect

The glaciers in the Amu Darya basin are mostly concentrated in the northeastern part of the country in the Wakhan corridor, which is a NE-SW elongated valley. Many of the other glaciers in Afghanistan are similarly situated in tectonic valleys, and this has a strong influence on glacier aspect.

Figure 5.5 shows the percentage of glaciers with different aspects and mean slope. Close to 21% of the glaciers had an east aspect, about 16% a southeast aspect, around 13 to 14% a northeast, south, southwest, or west aspect, 8% a northwest aspect, and only a very few glaciers (all within the Kokcha and Surkhab sub-basins) a north aspect.

## Slope

The mean slope of the glaciers in the basin ranged from 10° to 50°, with slopes of 20° to 30° most common and 40° to 50° least common in all cardinal directions. A negligible number had mean slopes less than 10° or above 50° (Figure 5.5).

The mean slope of the CI glaciers ranged from 24° to 26°, and of DC glaciers from 10° to 13° with slight basin-to-basin variations (Figure 5.6). These ranges are fairly typical for the HKH region.

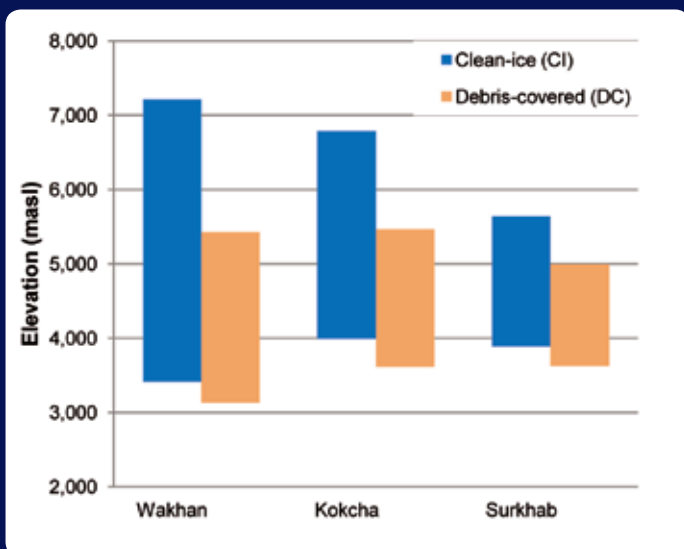
## Morphological glacier type

The morphological classification of glaciers in the Amu Darya basin is summarised in Table 5.4; the comparative distribution by number, area, and estimated ice reserves is shown graphically in Figure 5.7.

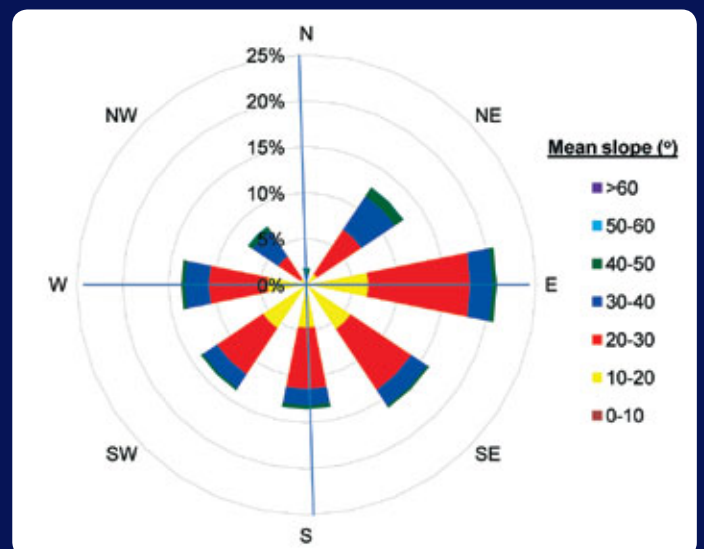
Just over 94% of the glaciers were identified as mountain type, the vast majority of them mountain basin type. Mountain glaciers had average areas ranging from 0.08 to 0.55 km<sup>2</sup>, covered 57% of the total glacier area, and contained 38% of the total ice reserves.

The valley glaciers in the Amu Darya basin have both compound basins and simple basins. The ice reserves of the valley glaciers are generally large because ice thickness increases with glacial area. The valley glaciers comprised less than 6% of the total by number, but with an average area of 5.79 km<sup>2</sup>, contributed almost 43% of the total glacier area and 62% of the total ice reserves (Table 5.4, Figure 5.7).

**Figure 5.4: Elevation of CI and DC glaciers in the sub-basins of the Amu Darya basin**



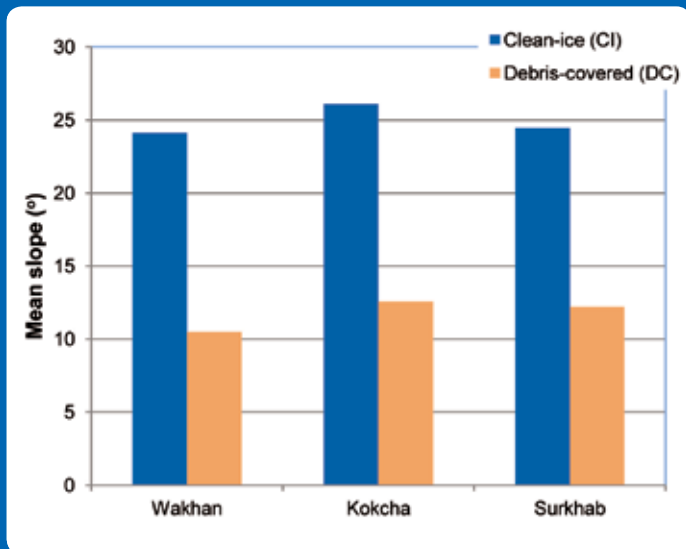
**Figure 5.5: Aspect and mean slope of glaciers in the Amu Darya basin**



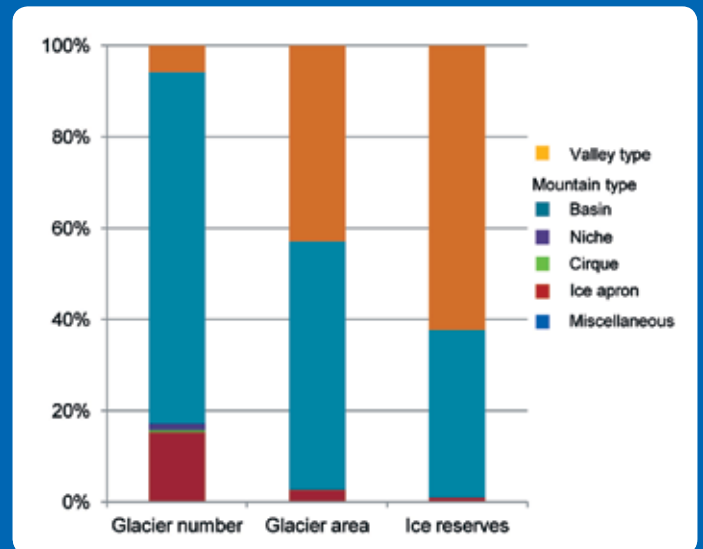
**Table 5.4: Morphological classification of glaciers in the Amu Darya basin**

Glacier type		Number		Area		Estimated ice reserves		Mean area per glacier
		Total	%	km <sup>2</sup>	%	km <sup>3</sup>	%	km <sup>2</sup>
Mountain	Miscellaneous	0	0.0	0.00	0.0	0.000	0.0	0.00
	Ice apron	500	15.3	67.20	2.6	1.512	0.9	0.13
	Cirque	18	0.6	1.81	0.1	0.033	0.02	0.10
	Niche	48	1.56	3.70	0.1	0.061	0.04	0.08
	Basin	2,521	76.9	1,393.32	54.3	59.741	36.7	0.55
Valley	Trough	190	5.8	1,100.14	42.9	101.262	62.3	5.79
<b>Total</b>		<b>3,277</b>	<b>100</b>	<b>2,566.18</b>	<b>100.0</b>	<b>162.609</b>	<b>100</b>	<b>0.78</b>

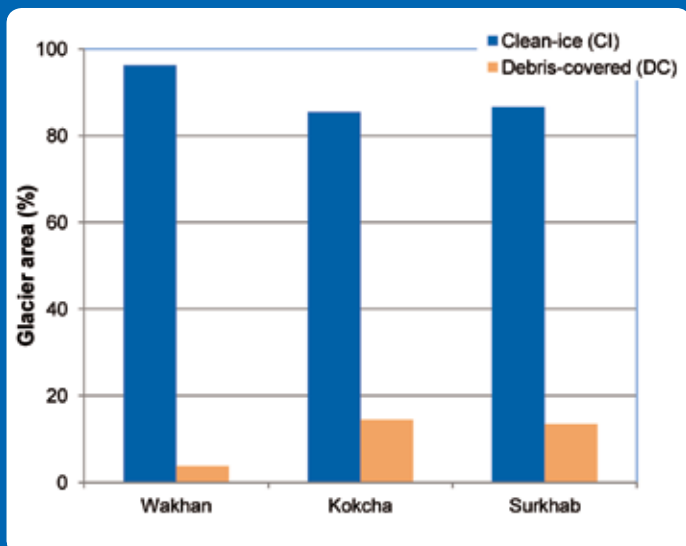
**Figure 5.6: Mean slope of CI and DC glaciers in the sub-basins of the Amu Darya basin**



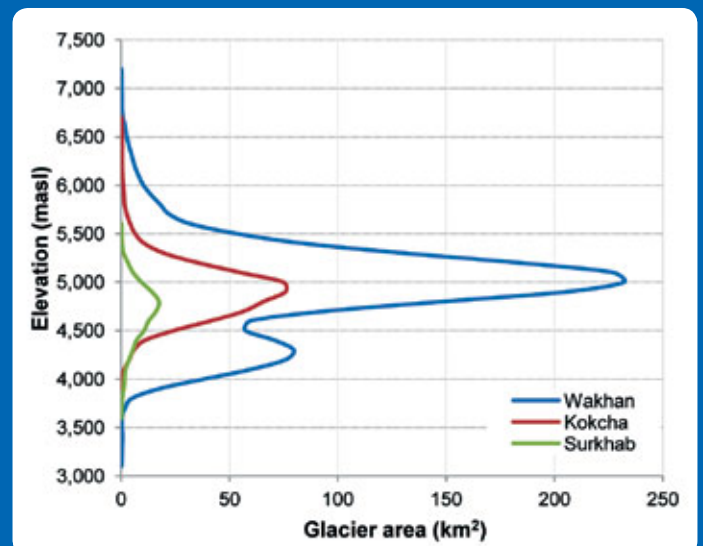
**Figure 5.7: Comparative distribution of different glacier types in the Amu Darya basin by number, area, and estimated ice reserves**



**Figure 5.8: Percentage distribution by area of CI and DC glaciers in the sub-basins of the Amu Darya basin**



**Figure 5.9: Area-altitude distribution of glaciers in the sub-basins of the Amu Darya basin within the HKH region**



### Clean-ice and debris-covered glaciers

Only 282 (9%) of the 3,277 glaciers in the basin had both CI and DC components. In total, 160 km<sup>2</sup> or 6% of the total glacier area was debris covered. The lowest DC area was found in the Wakhan basin and the highest in the Surkhab basin (Figure 5.8).

### Hypsography

The glacier area-altitude distribution in the three sub-basins is shown in Figure 5.9. The maximum glaciated areas were 232.22 km<sup>2</sup> at 5,000-5,100 masl in the Wakhan sub-basin, 75.81 km<sup>2</sup> at 4,900-5,000 masl in the Kokcha sub-basin, and 17.41 km<sup>2</sup> at 4,800-4,900 masl in the Surkhab sub-basin. The Wakhan sub-basin had the highest elevation band (7,200 masl) followed by the Kokcha sub-basin (6,700 masl). The Wakhan sub-basin showed a distinctive bimodal area-altitude distribution.