# Supplementary Materials f

**Table 1.** We calculated $ET_0$ using the Hamon (1963) method because of climate data are limited, and it has been shown to provide reasonable potential evapotranspiration for forested regions [1-3]. The Hamon method computes daily $ET_0$ based on air temperature and daytime length

$$E_0 = K \times 0.1651 \times DAY \times \frac{216.7 \times e_s}{t_a + 273.3} \tag{1}$$

where $DAY$ is the day length in multiples of 12h calculated as a function of latitude $(Lat)$ and Julian day, $e_s$ is the saturation vapor pressure at a given temperature, and $t_a$ is the mean air temperature (℃), $K$ is a correction coefficient to adjust $E_0$ from the Hamon's method to reflect realistic values for $E_0$. Due to the expected low potential evapotranspiration in the cold study watershed, the $K$ value was set to be 1.1 [3,4]

The saturation vapor pressure, $e_s$, is calculated as follows:

$$e_s = 6.108 \times e\frac{17.2694 \times t_a}{t_a + 237.3} \tag{2}$$

The day length is calculated as follows [5]:

$$\varphi = radians(360 \times \frac{d}{365}) \tag{3}$$

$$\delta = -radians(0.39637 - 22.9133 \times cos\,\varphi + 4.02543 sin\varphi - 0.3872 cos2\varphi + 0.052 sin2\varphi) \tag{4}$$

$$N = 0.133 \times degrees\{cos^{-1}[-\,tan\,\delta \times tan(-radians(Lat)]\} \tag{5}$$

where $d$ is the day number, ranging from 0 on 1 January to 364 on 31 December; $N$ is the day length.

**Table S1 and Figure S1** summaries the change in the impact of climate and forest component changes on streamflow results for the three periods when using the eight sensitivity-based approaches. Overall, the eight independent methods produced very similar results.

**Table 1.** The change in streamflow for the different period when using the eight sensitivity-based approaches.

| | | **1984-1994** | | | | **1995-2005** | | | | **2006-2016** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Climate** | | **Forest** | | **Climate** | | **Forest** | | **Climate** | | **Forest** | |
| **Approach** | | **mm** | **%** | **mm** | **%** | **mm** | **%** | **mm** | **%** | **mm** | **%** | **mm** | **%** |
| Budyko Hypothesis | *Schreiber* | 17.3 | 8.0 | 35.9 | 16.6 | 3.4 | 1.6 | 22.6 | 10.4 | 24.5 | 11.3 | 19.0 | 8.8 |
| | *Ol'dekop* | 18.8 | 8.7 | 34.3 | 15.8 | 1.9 | 0.9 | 24.2 | 11.2 | 25.9 | 12.0 | 17.6 | 8.1 |
| | *Budyko* | 18.7 | 8.6 | 34.4 | 15.9 | 1.9 | 0.9 | 24.1 | 11.1 | 25.9 | 11.9 | 17.6 | 8.1 |
| | *Turc-Pike* | 18.0 | 8.3 | 35.2 | 16.2 | 2.7 | 1.3 | 23.4 | 10.8 | 25.2 | 11.6 | 18.3 | 8.5 |
| | *Fu* | 17.4 | 8.0 | 35.8 | 16.5 | 3.4 | 1.6 | 22.7 | 10.5 | 24.6 | 11.3 | 18.9 | 8.7 |
| | *Zhang* | 18.6 | 8.6 | 34.6 | 15.9 | 2.1 | 1.0 | 24.0 | 11.1 | 25.7 | 11.9 | 17.8 | 8.2 |
| Non-parametric Method | Equation (10) | 12.7 | 5.8 | 40.5 | 18.7 | 5.8 | 2.7 | 20.3 | 9.4 | 22.4 | 10.3 | 21.1 | 9.7 |
| | Equation (11) | 19.8 | 9.1 | 33.4 | 15.4 | 6.3 | 2.9 | 19.8 | 9.1 | 17.5 | 8.1 | 26.0 | 12.0 |
| Mean | | 17.7 | 8.1 | 35.5 | 16.4 | 3.4 | 1.6 | 22.7 | 10.4 | 24.0 | 11.1 | 19.5 | 9.0 |

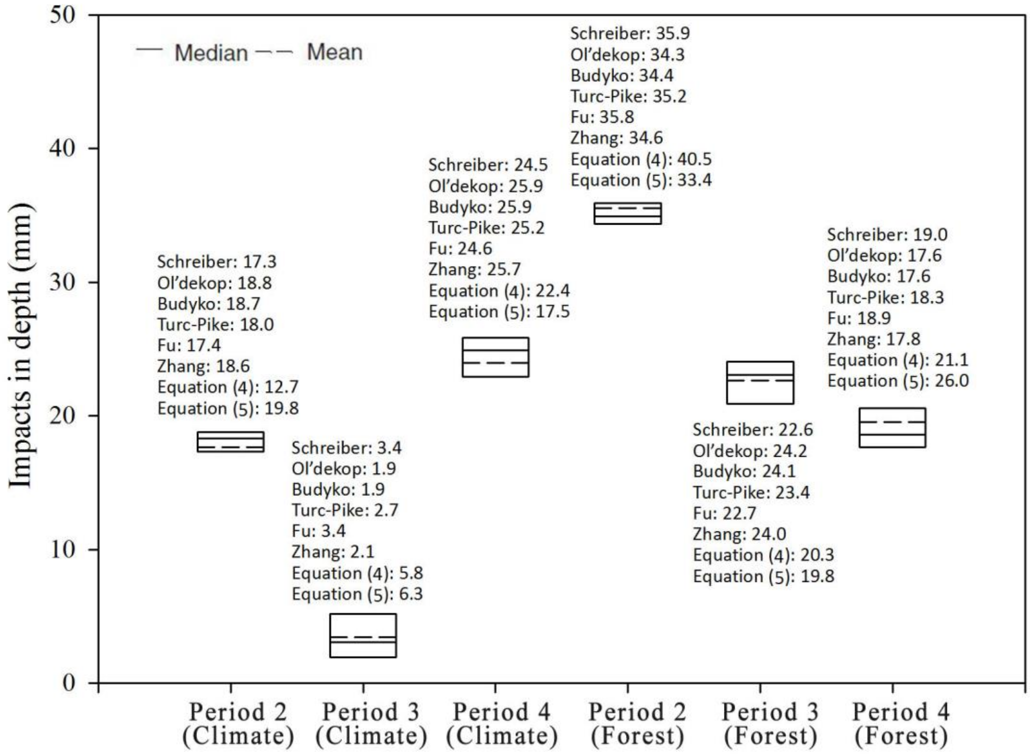


**Figure 1.** Changes in streamflow depth during the three periods due to forest structure and climate change estimated by the eight approaches.

**Table S2-S4**: the paired year approach used in this study to find the paired year.

The statistic results showed that P and Tmax significantly correlated with high flow, and P, Tmean and Tmin significantly correlated with low flow (Table S2). Then the identified climatic variables were used to select the paired years (Table S3 and Table S4).

**Table 2.** Correlation analysis between hydrological variables (high and low flow) and climatic variable.

| Variability | | P | Tmean | Tmax | Tmin | Wind |
|---|---|---|---|---|---|---|
| High flow | MK | **0.524** | −0.090 | **−0.182** | 0.080 | −0.008 |
| | Spearman | **0.703** | −0.123 | **−0.268** | 0.138 | 0.004 |
| Low flow | MK | **0.301** | **0.208** | 0.193 | **0.242** | −0.199 |
| | Spearman | **0.415** | **0.328** | 0.299 | **0.371** | −0.208 |

MK and Spearman represent as Kendall's tau and Spearman correlation analyses. P, Tmean, Tmax, Tmin and Wind represent as the annual precipitation, mean annual mean/maximum/minimum temperatures. Bold italics underlined values indicate the trends with a statistical significance of $p < 0.01$. Bold italics values indicate the trends with a statistical significance of $p < 0.05$.

**Table 3.** The selected pairs for high flow.

| Period | Selected year | Paired year | P /mm | | Tmax /℃ | |
|---|---|---|---|---|---|---|
| Period 1–Period 2 | 1981 | 1993 | 489 | 488 | 5.0 | 6.0 |
| Period 1–Period 3 | 1978 | 1999 | 567 | 573 | 5.3 | 5.2 |
| Period 1–Period 4 | 1978 | 2006 | 567 | 555 | 5.3 | 5.43 |
| Period 2–Period 3 | 1990 | 2003 | 650 | 645 | 7.1 | 6.1 |
| Period 2–Period 4 | 1990 | 2009 | 650 | 652 | 7.1 | 4.7 |
| Period 3–Period 4 | 2012 | 2000 | 463 | 447 | 5.5 | 5.6 |

**Table 4.** The selected pairs for low flow.

| Period | Selected year | Paired year | P/mm | | Tmean /℃ | | Tmin /℃ | |
|---|---|---|---|---|---|---|---|---|
| Period 1 - Period 2 | 1981 | 1994 | 489 | 486 | -2.7 | -1.9 | -9.6 | -8.5 |
| Period 1 - Period 3 | 1974 | 2000 | 446 | 447 | -3.6 | -2.9 | -10.7 | -10.1 |
| Period 1 - Period 4 | 1976 | 2007 | 435 | 440 | -3.8 | -1.0 | -11.0 | -8.7 |
| Period 2- Period 3 | 1987 | 1996 | 541 | 548 | -3.7 | -3.0 | -10.6 | -10.3 |
| Period 2 - Period 4 | 1985 | 2011 | 478 | 473 | -2.9 | -1.7 | -9.5 | -9.1 |
| Period 3 - Period 4 | 1996 | 2010 | 548 | 552 | -3.0 | -2.4 | -10.3 | -9.6 |

**Figure S2-S7:** the precipitation duration curve (PDC) and Flow duration curve (FDC) in paired years.

Figure S2-S4 showed the high flow for the selected paired years in FDCs and PDCs.

Figure S5-S7 showed the low flow for the selected paired years in FDCs and PDCs.

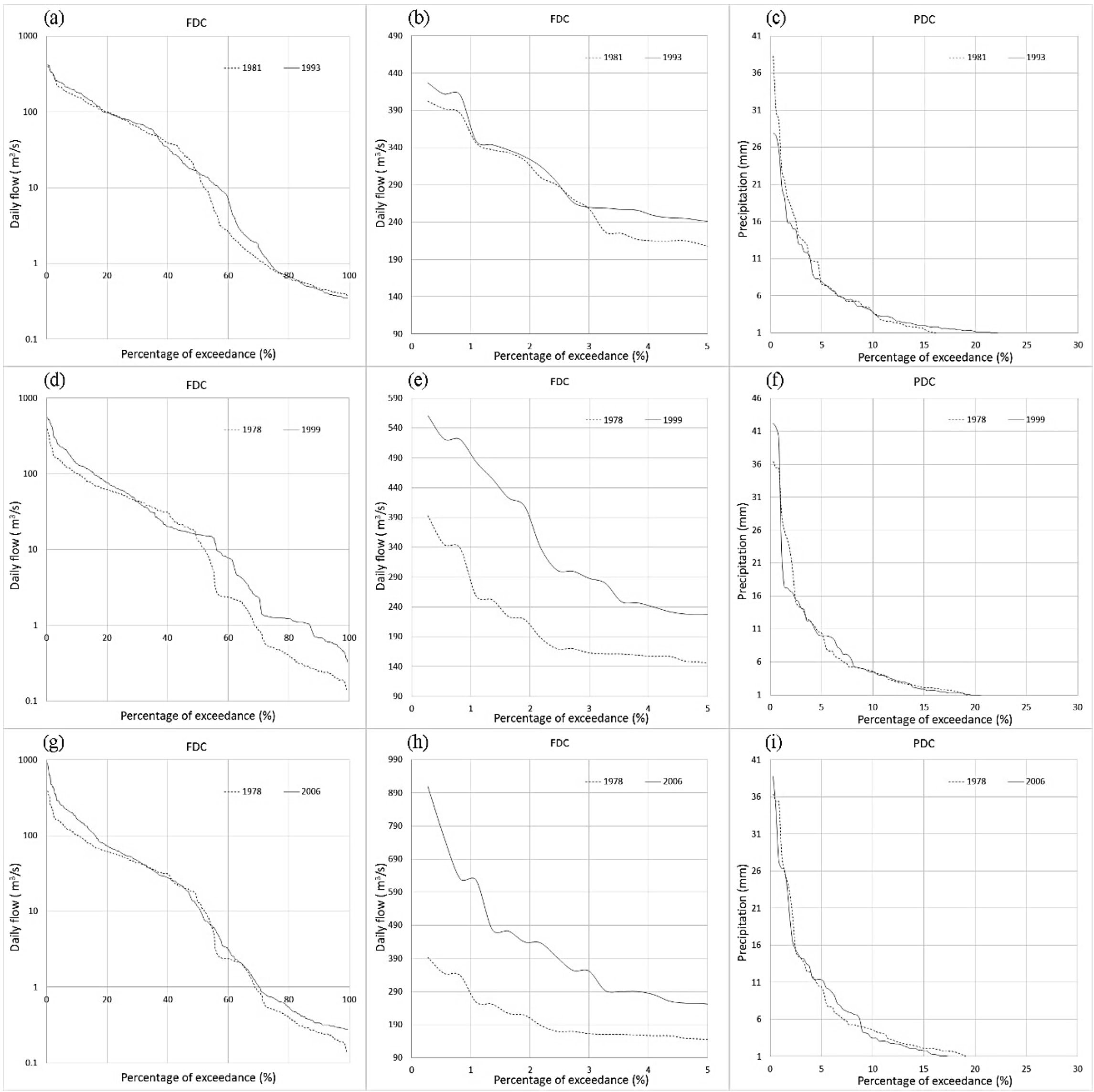


**Figure 2.** Based on Period 1, FDCs and PDCs for the selected paired years in high flow: (a) FDCs for 1981-1993, (b) high flow for 1981-1993, (c) PDCs for 1981-1993, (d) FDCs for 1978-1999, (e) high flow for 1978-1999, (f) PDCs for 1978-1999, (g) FDCs for 1978-2006, (h) high flow for 1978-2006, (i) PDCs for 1978-2006.

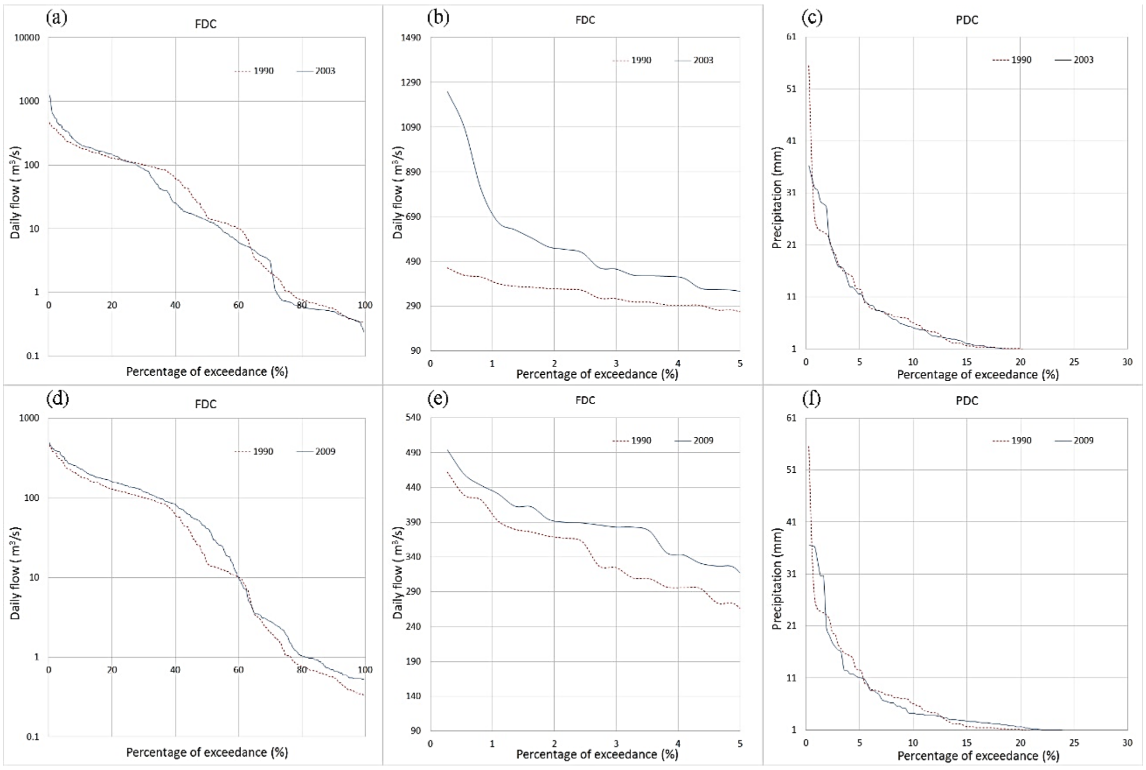


**Figure 3.** Based on Period 2, FDCs and PDCs for the selected paired years in high flow: (a) FDCs for 1990-2003, (b) high flow for 1990-2003, (c) PDCs for 1990-2003; (d) FDCs for 1990-2009, (e) high flow for 1990-2009, (f) PDCs for 1990-2009.

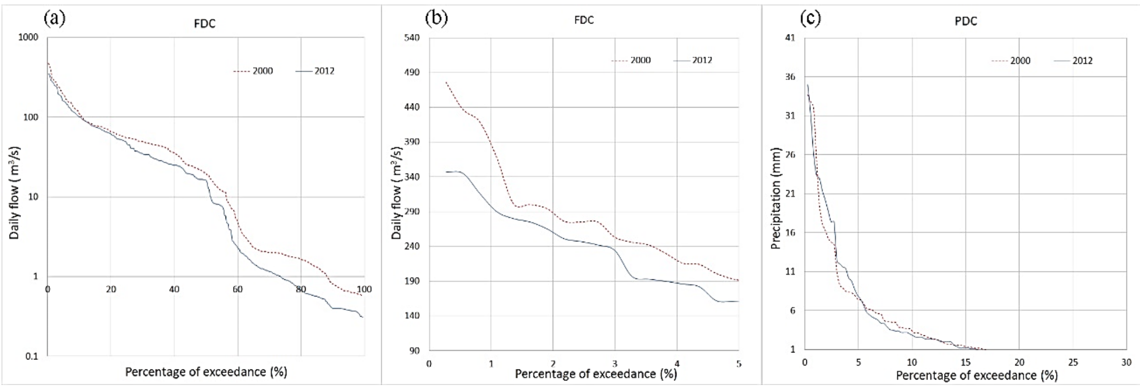


**Figure 4.** Based on period 3, FDCs and PDCs for the selected paired years in high flow: (a) FDCs for 2000-2012, (b) high flow for 2000-2012, (c) PDCs for 2000-2012.

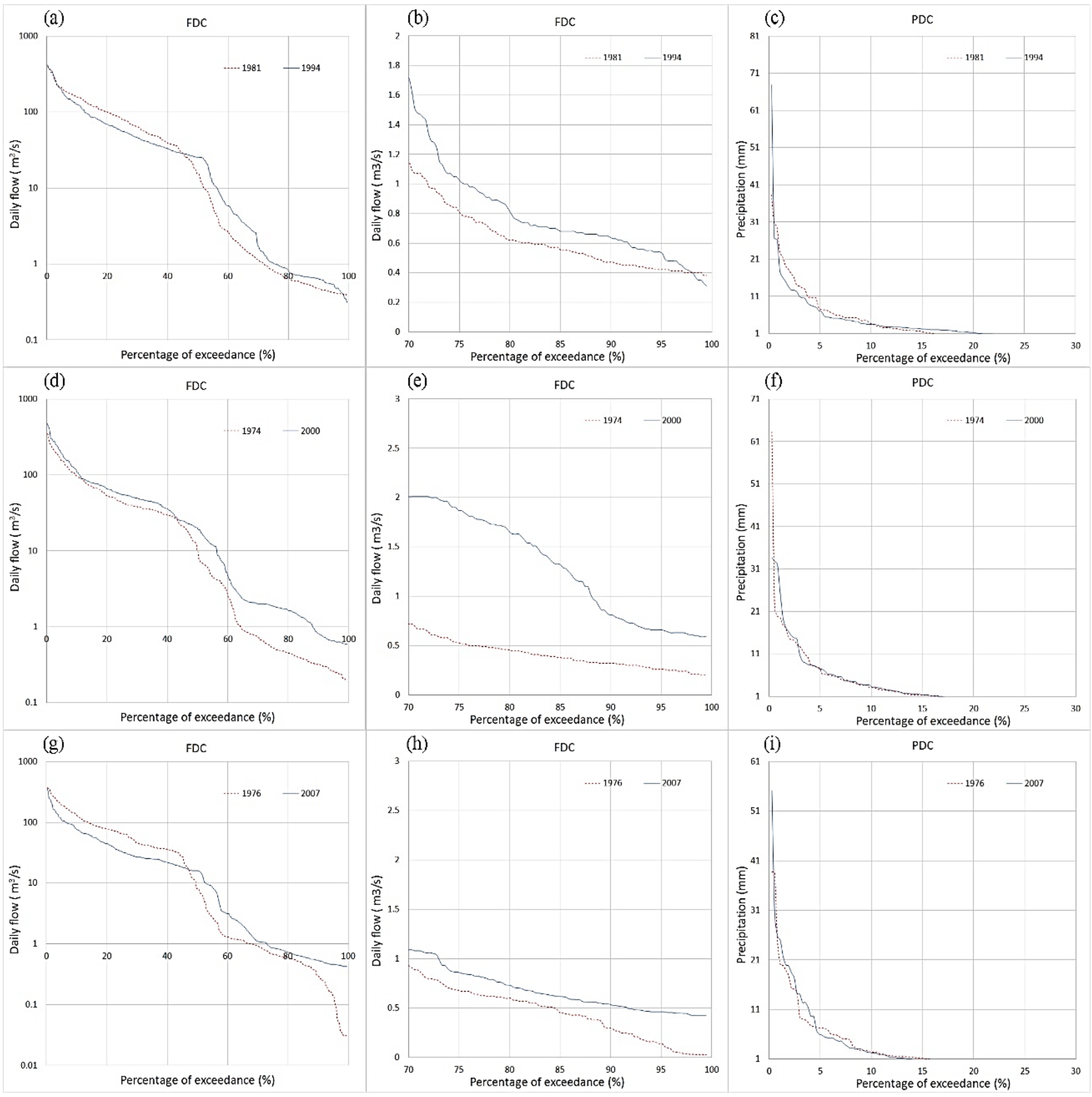


**Figure 5.** Based on Period 1, FDCs and PDCs for the selected paired years in low flow: (a) FDCs for 1981-1994, (b) low flow for 1981-1994, (c) PDCs for 1981-1994, (d) FDCs for 1974-2000, (e) low flow for 1974-2000, (f) PDCs for 1974-2000 (g) FDCs for 1976-2007, (h) low flow for 1976-2007, (i) PDCs for 1976-2007.

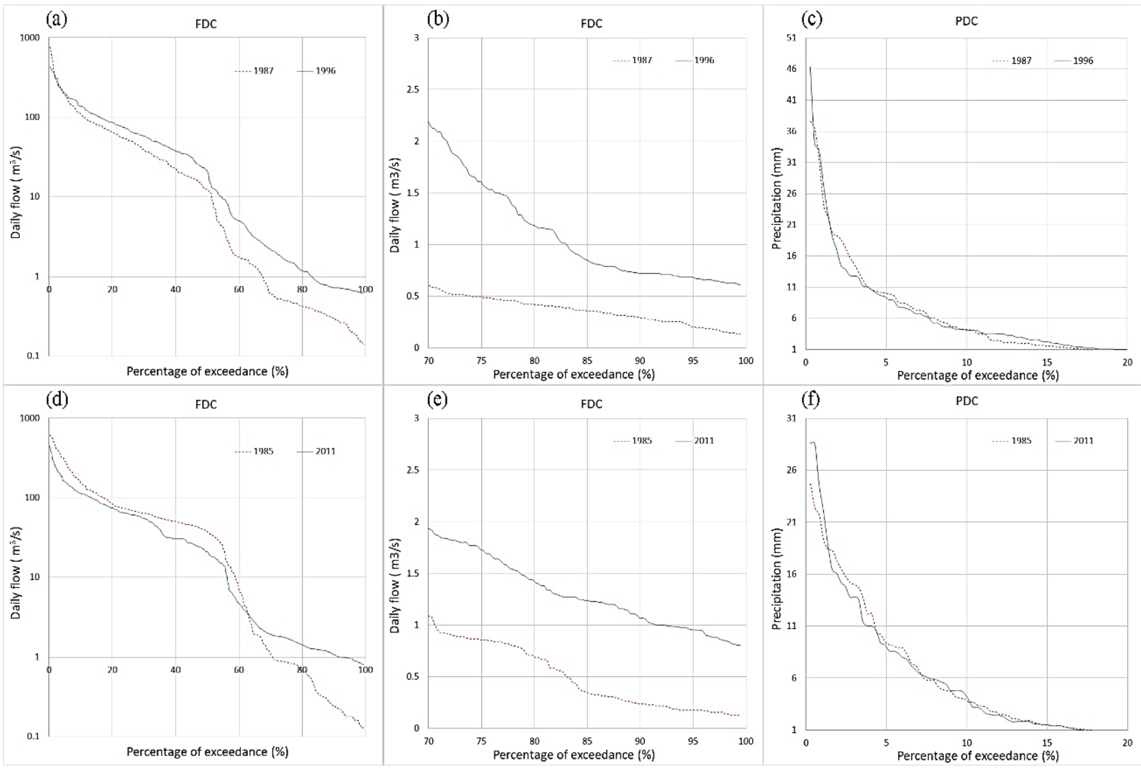


**Figure 6.** Based on Period 2, FDCs and PDCs for the selected paired years in low flow: (a) FDCs for 1987-1996, (b) low flow for 1987-1996, (c) PDCs for 1987-1996; (d) FDCs for 1985-2011, (e) low flow for 1985-2011, (f) PDCs for 1985-2011.

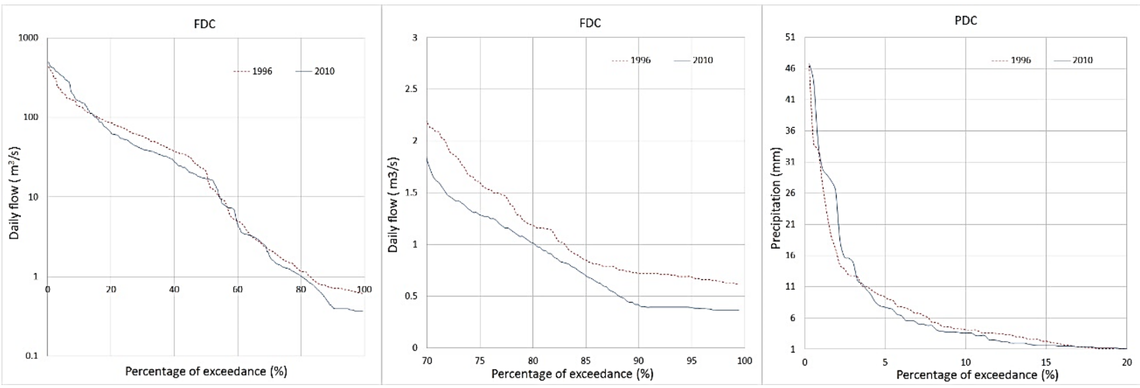


**Figure 7.** Based on Period 3, FDCs and PDCs for the selected paired years in low flow: (a) FDCs for 1996-2010, (b) low flow for 1996-2010, (c) PDCs for 1996-2010.

## References

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