Supplementary Material for "Time Series of Landsat Imagery Shows Vegetation Recovery in Two Fragile Karst Watersheds in Southwest China from 1988 to 2016"

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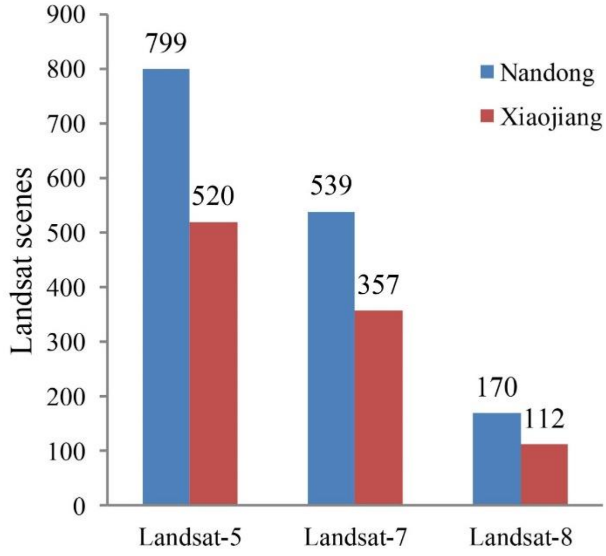

Figure S1. The amount of Landsat scenes collected and processed via the Google Earth Engine platform in Nandong and Xiaojiang watersheds from 1988 to 2016.

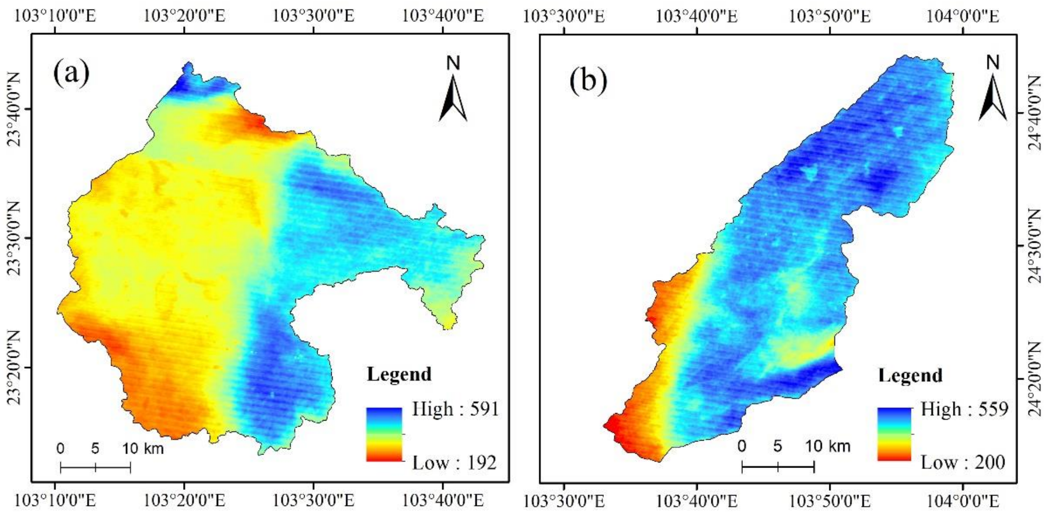

Figure S2. The spatial distribution of the good-quality Landsat observation numbers at the pixel scale from 1988 to 2016 in: (a) Nandong and (b) Xiaojiang watershed.

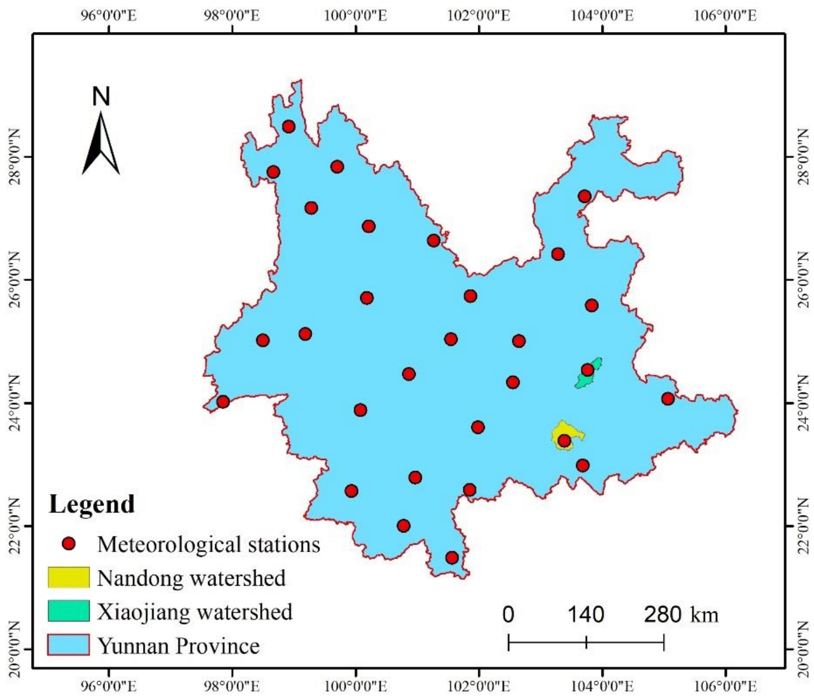

Figure S3. The spatial distribution of the 29 meteorological ground stations across Yunnan Province, southwest China.

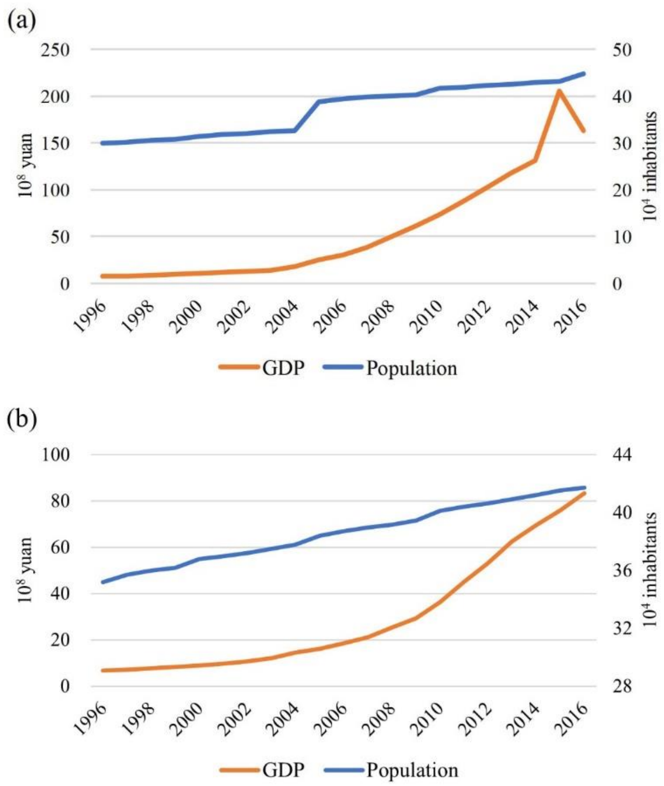

Figure S4. The socioeconomic development during 1996-2016 in (a) Nandong and (b) Xiaojiang watersheds.

Correlation between Vegetation Cover and Climate Change

In this study, at the watershed level, there were no significant correlations observed between vegetation change and climatic variables (i.e., temperature and precipitation) in both watersheds (Figure S5). Meanwhile, at the pixel level, 14% and 7% of all pixels in Nandong exhibited a significant ($p < 0.05$) positive and negative correlation between temperature and the annFVC during 1988-2016, respectively (Figure S6a). In Xiaojiang, temperature was significantly positively correlated with the annFVC in 16% of all pixels and no negative correlation was found (Figure S6g). Consequently, 79% and 84% of pixels showed no significant correlations between temperature and the annFVC in Nandong and Xiaojiang watersheds, respectively. Additionally, the relationship between precipitation and the annFVC was even weaker than temperature since up to 92% and 95% of pixels had no significant correlations between the two variables (Figure S6d,j). This is largely because the climatic conditions in karst areas of southwest China are characterized by subtropical monsoon with abundant precipitation together with moderate temperature. Thus, unlike arid and semi-arid areas where rainfall availability is a primary limiting factor that affects vegetation growth, vegetation growth is not sensitive to slight changes in precipitation in karst areas. To compare the responses of vegetation change to climate variables between the reference and conservation periods, we also conducted separate partial correlation analysis for both periods (Figure S6). Statistically insignificant and weaker correlations were found in more pixels in both periods relative to the whole period 1988-2016, suggesting other non-climate factors might be responsible for the increased greenness.

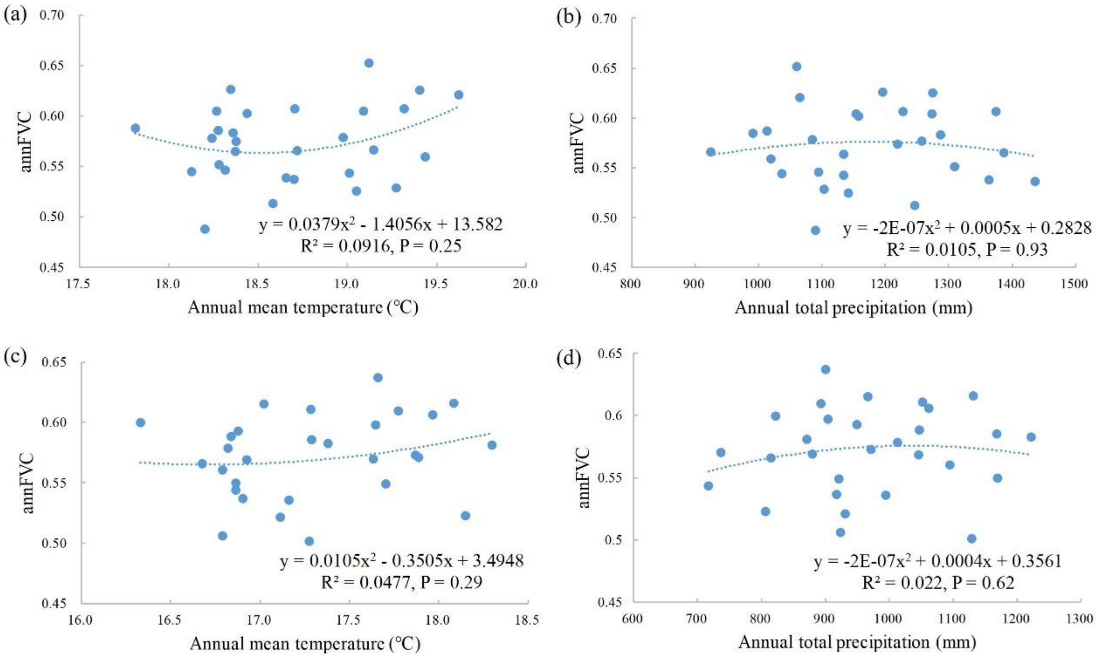

Figure S5. The relationships between annual fractional vegetation cover (annFVC) and spatially averaged annual mean temperature (a: Nandong, c: Xiaojiang) together with annual total precipitation (b: Nandong, d: Xiaojiang) during 1988-2016.

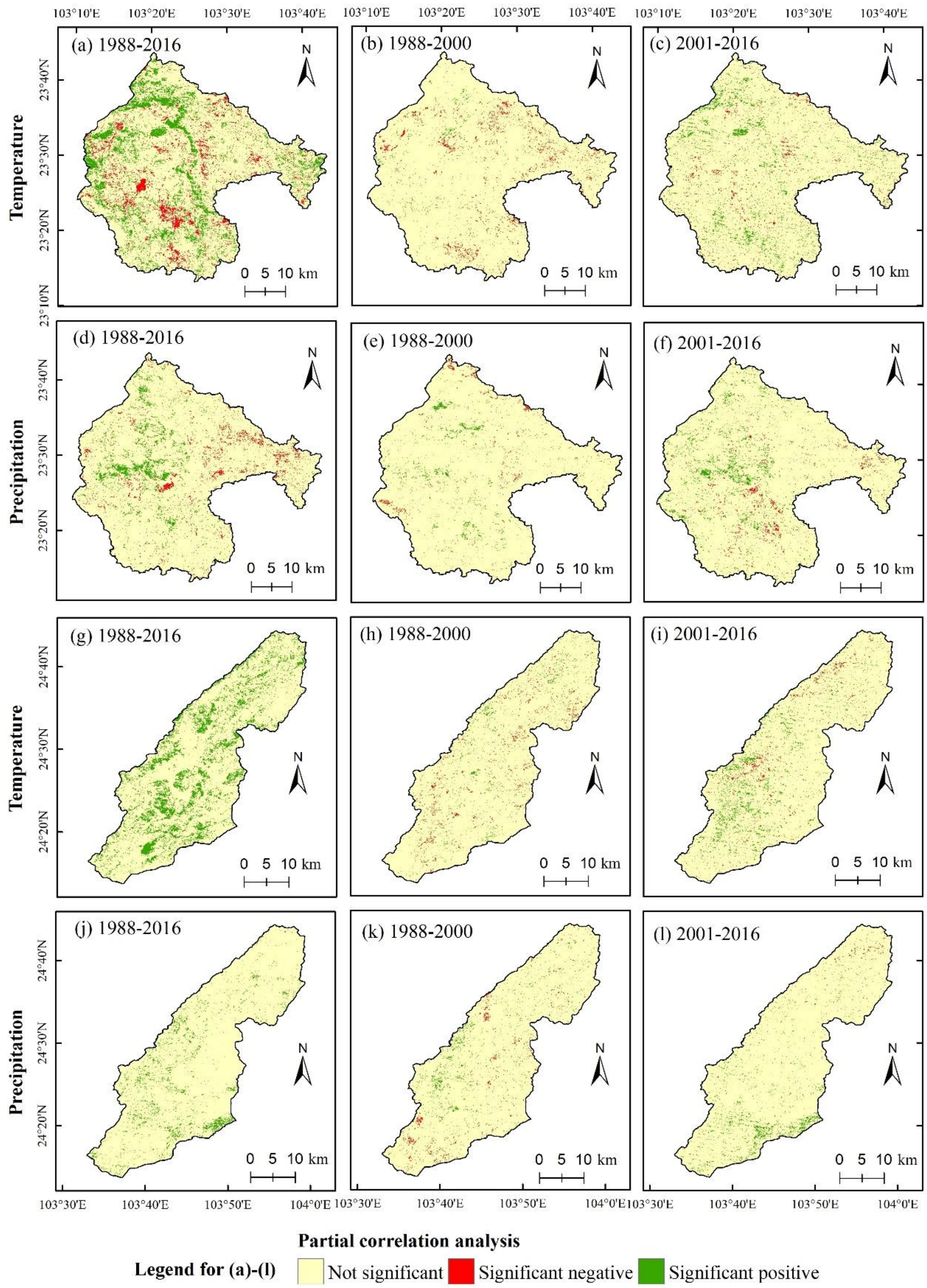

Figure S6. The spatial distribution of the relationships in the Nandong watershed between annFVC and annual mean temperature: (a) full time series (1988-2016); (b) reference period (1988-2000); (c) conservation period (2001-2016); and the spatial distribution of the relationships between annFVC and annual total precipitation: (d) full time series (1988-2016); (e) reference period (1988-2000); (f) conservation period (2001-2016); and the spatial distribution of the relationships in the Xiaojiang watershed between annFVC and annual mean temperature: (g) full time series (1988-2016); (h) reference period (1988-2000); (i) conservation period (2001-2016); and the spatial distribution of the relationships between annFVC and annual total precipitation: (j) full time series (1988-2016); (k) reference period (1988-2000); (l) conservation period (2001-2016).

Both watersheds generally presented warmer and drier climatic characteristics over the last 29 years under global warming (Figure S7). Specifically, temperature significantly increased at an annual rate of 0.037 °C ($r = 0.67$, $p < 0.001$) in Nandong (Figure S7a) and 0.040 °C ($r = 0.66$, $p < 0.001$) in Xiaojiang watershed (Figure S7c) during 1988-2016. It is noticeable that for both watersheds, temperature increased at an accelerating rate in the conservation period compared with years prior to 2001. In contrast, precipitation showed overall insignificant downtrends at an annual rate of 3.55 mm ($r = -0.23$, $p = 0.23$) in Nandong (Figure S7b) and 3.20 mm ($r = -0.21$, $p = 0.27$) in Xiaojiang (Figure S7d) during 1988-2016. The conservation period witnessed reduced rainfalls in comparison to the reference period.

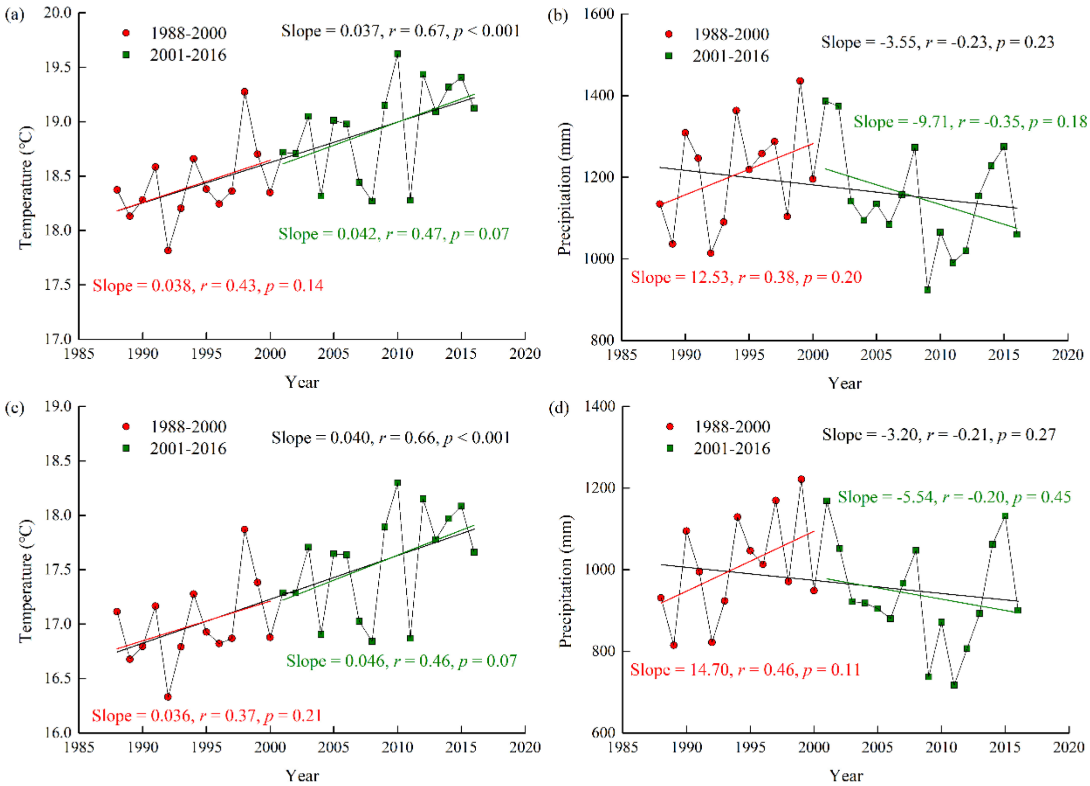

Figure S7. Climate change during the last 29 years in the karst watersheds of Nandong and Xiaojiang watersheds: temporal trends in temperature for (a) Nandong; and (c) Xiaojiang; and precipitation (b) Nandong; (d) Xiaojiang. Slopes of the period and their corresponding significance levels were also shown. The black solid line represents the regression fit to the climate data during 1988-2016, while red line and green line denote the regression fit to the climate data during 1988-2000 and 2001-2016, respectively.