**Supplemental file 1 (SF 1):**

**Water-related ecosystem services evaluation models**

**Water yield (WY) model:** Water retention service is defined as the ability of ecosystems to retain water resources from rainfall, which can be quantitatively described as annual water yield. The annual water yield for pixel  on ,  (mm/yr), is estimated based on annual average precipitation and the Budyko curve (Budyko 1974) as follows:



where,  (mm/yr) is the annual actual evapotranspiration for pixel  on  , and (mm/yr) is the annual precipitation for pixel  .

For vegetated LULC, the evapotranspiration portion of the water balance, , is based on an expression of the Budyko curve proposed by Fu 1981 and Zhang et al. 2004:



where  is the potential evapotranspiration and  is a non-physical parameter that characterizes the natural climatic-soil properties.

Potential evapotranspiration is defined as:



where is the reference evapotranspiration from pixel  and is the vegetation evapotranspiration coefficient associated for pixel  on .





where  is a non-physical parameter that characterizes the natural climatic-soil properties;  is a dimensionless constant that represents the local features of precipitation and hydrogeology, ranging from 1 to 30;  (mm) is the volumetric plant available water content; the *1.25* term is the minimum value of  (Donohue et al. 2012);  (mm) is the plant available water capacity.

For non-vegetated LULC (e.g., open water, developed land), the annual actual evapotranspiration is computed directly from the reference evapotranspiration and has an upper limit defined by the precipitation:



where  is evapotranspiration coefficient for pixel  on , is the reference evapotranspiration from pixel and  (mm/yr) is the annual precipitation for pixel .

In the current study, we define “water scarcity” as the discrepancy between the total water yield and the total demand of water, to measure the satisfaction of water retention service. Water scarcity is calculated using the *Realized Supply model*:



where (m3/yr) is the estimated water scarcity, (m3/yr) is the total water yield, (m3/yr) is the total volume of water demand including the industrial, agricultural, domestic and ecological components.

**Nutrient Delivery Ratio (NDR) model:** Although there are multiple potential factors affecting water quality, the main causes of water pollution in the THB are nitrogen and phosphorus pollutants, as indicated by the frequent outbreaks of cyanobacteria (Guo 2007; Qin et al. 2010). Therefore, the water purification service in this study refers to the ecosystem’s capacity to absorb nitrogen and phosphorus from the water flows. Sources of nutrient across the landscape are determined based on the land use map and associated loading rates. Each pixel’s actual load is modified based on the precipitation to account for the local runoff potential. Nutrient export from each pixel is calculated based on the product of the load and the nutrient delivery ratio.

The NDR model illustrates the process of nutrients export to streams, and the exported nutrients are calculated as follows:



Based on the original load, each pixel’s estimated load is modified by the local runoff potential index, and the ratio between surface and subsurface nutrient sources is given by the parameter. Therefore, the load (kg·ha-1·yr-1) for pixel  is given by:





where  is the runoff potential index for pixel , is the nutrient runoff proxy for runoff on pixel  and  is the average  over the raster.

Precisely, the delivery ratios  are calculated as follows:

(1) Surface NDR: The surface NDR is determined by the ability of downstream pixels to transport nutrient,, together with the topographic index, , for pixel :



where  and  are calibration parameters;  is a topographic index, and is the proportion of nutrient that is not retained by downstream pixels.





where  is retention efficiency for pixel , is the maximum retention efficiency of , is the retention efficiency on the pixel directly downstream from pixel , and is the step factor defined as:



where  is the length of the flow path from pixel  to its downstream neighbour,  is the LULC retention length on pixel  .

 is the index of connectivity:





where (m/m) and  (m2) are theaverage slope gradient and the total area of the upslope contributing area, respectively,  (m) is the length of the flow path along the pixel .

(2) Subsurface NDR:



where is the maximum nutrient retention efficiency the subsurface flow can reach,  is the distance from the pixel to the stream,  is the subsurface flow retention length.

**Sediment Delivery Ratio (SDR) model:** Soil retention service accounts for the retention by vegetation of rainfall-eroded soil, for the protection of soil resources and water quality. The InVEST sediment delivery model is to map overland sediment generation and delivery to the stream. The sediment export from a pixel ,  (ton·ha-1·yr-1), and the total sediment export of the evaluate area,  (ton·ha-1·yr-1), is given by:



The amount of annual soil loss on pixel , , is given by the revised universal soil loss equation:



where  (MJ·mm·(ha·hr)-1) is the rainfall erosivity,  (ton·ha·hr·(MJ·ha·mm)-1) is the soil erodibility,  is the slope length-gradient factor,  is the crop-management factor, and  is the support practice factor.

The connectivity index  is given by:



 is the upslope component defined as:



where  is the average  factor of the upslope contributing area,  (m/m) is the average slope gradient of the upslope contributing area and  (m2) is the upslope contributing area, and,  is the downslope component, defined as:



where  and  are the  factor and the slope gradient on pixel ,  (m) is the length of the flow path along the pixel .

The SDR for a pixel , , is derived from the connectivity index :



where  is the maximum theoretical SDR,  and  are calibration parameters that define the shape of the SDR-IC relationship.