use or water pollution (*11*). Runoff is accumulated through river channels and forms river discharge (Fig. 2B). River discharge can be considered as the potentially maximum available RFWR if all the water from upstream can be used. Both runoff and river discharge are concentrated in limited areas, and the amounts range from nearly zero in desert areas through more than 2000 mm/year of runoff in the tropics and more than 200,000 m^3/s of discharge on average near the river mouth of the Amazon. Furthermore, the water demands for ecosystems and navigation should also be met, and all the RFWR cannot be used only for human beings.

How Are the World Water Resources Assessed?

In the late 1960s, the International Hydrological Decade promoted studies on world water balances, and pioneering estimates were published in the 1970s (*5*, *12*, *13*). Shiklomanov (*4*) assembled country statistics on water withdrawals in the past and present and made future projections. Recent advances in information technologies have enabled global water-balance estimations at finer spatial resolution (*11*, *14*, *15*). Water withdrawals now can be distributed into grid boxes, using the distributions of population and the irrigation area as proxies, and compared with the available RFWR in each grid box (*11*, *14*, *15*).

The water scarcity index is defined as $Rws = (W - S)/Q$, where W, S, and Q are the annual water withdrawal by all the sectors, the water use from desalinated water, and the annual RFWR, respectively. A region is usually considered highly water stressed if Rws is higher than 0.4 (*7*, *11*, *14*, *15*). It is considered to be a reasonable, although not definitive, threshold value because not all the RFWR can be used by human society. Data with shorter time scales will enable more detailed assessments considering the effects of temporal variability in the hydrological cycles.

In the era of the "Anthropocene" (*16*), where human impacts on natural processes are large and widespread, it no longer makes sense to study only natural hydrological cycles. For this reason, some studies have started to consider the impact of human interventions on the hydrological cycles, thereby simulating more realistically the hydrological cycles on a global scale. In such studies, human withdrawals are subtracted from the river flow (*15*), and the regulation of flow regime by major reservoirs is incorporated (*17*).

The distribution of the water scarcity index Rws (*11*), recalculated with the latest multimodel ensemble estimates (*3*), is shown in Fig. 2C. Rws is high in Northern China, in the area on the border between India and Pakistan, in the Middle East, and in the middle and western areas of the United States. Based on this assessment, approximately 2.4 billion people are currently living in highly water-stressed areas (*18*).

Can the "Virtual Water Trade" Alone Save the Water-Stressed Regions?

Transporting water over long distances, from regions where water is abundant to dry regions under water stress, is only feasible when gravity can be used. The demand for high-quality drinking water is limited to a few liters per person per day and can be met through international trade or by desalination. However, other demands for water for households, industry, and agriculture require up to one metric ton of water per day per

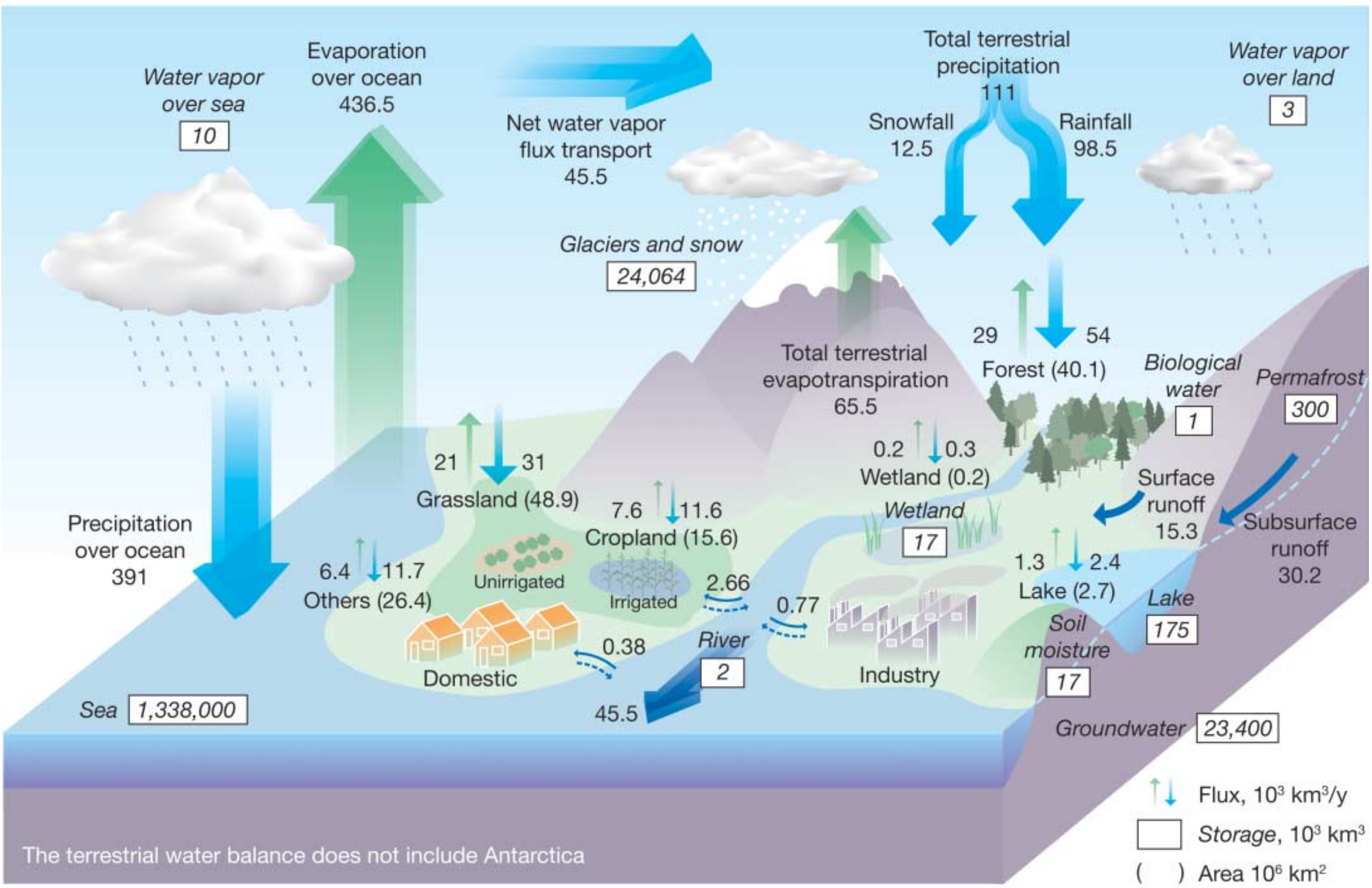

Fig. 1. Global hydrological fluxes (1000 km^3/year) and storages (1000 km^3) with natural and anthropogenic cycles are synthesized from various sources (*1*, *3*–*5*). Big vertical arrows show total annual precipitation and evapotranspiration over land and ocean (1000 km^3/year), which include annual precipitation and evapotranspiration in major landscapes (1000 km^3/year) presented by small vertical arrows; parentheses indicate area (million km^2). The direct groundwater discharge, which is estimated to be about 10% of total river discharge globally (*6*), is included in river discharge.