Spatially explicit analysis of regional freshwater boundary exceedances embodied in international trade

Topic: Sustainable Production and Consumption Policies
Author: Jingwen Huo
Co-Authors: Xu Zhao

The regional freshwater boundary set restrictions on water use, and the regional freshwater boundary exceedances (RFB exceedances) not only poses a threat to national sustainable development but also has further global impacts through the transmission of global supply chains. Considering the regional heterogeneity in water resource endowments and water consumption, we analyzed the RFB exceedances embodied in global trade at grid scale.

We estimate the RFB exceedances embodied in trade by using the EMERGING MRIO tables (covering 245 economies and 135 sectors) in 2015 and the emissions embodied in mutual trade (EEBT) method, which analyzes mutual interconnection between industries in different regions due to trade-adjusted emission changes and assess attributions of environmental changes both from production and consumption. We also construct the inventory of water withdrawal and RFB exceedances based on global gridded water withdrawal across five sectors (Irrigation, Livestock, Manufacturing, Electricity, and Domestic), to link with the EMERGING. Here, we found that East Asia, North America, and West Asia are the main importers of RFB exceedances, while Central and South Asia are the main exporters, accounting for 46.4% of global total RFB exceedances embodied in imports and exports, respectively.

Due to the southward shift of industries, in addition to the traditional agricultural sector, the exports of machinery manufacturing and textile sectors are also the main contributors for RFB exceedances, especially in emerging economies. For example, in 2015, the net export volume of embodied RFB exceedances in India's petrochemical sector trade was 9.8 km3, accounting for 10.1% of the total net export volume of embodied RFB exceedances. China's Textile, Machinery, and Equipment sectors have the net export volume of 25.2 and 23.8 km3 of embodied RFB exceedances, accounting for 70.0% and 65.9% of the total net export volume of embodied RFB exceedances, respectively. This will lead to increased water pressure in major exporters such as China and India in their central urban cities and surrounding watersheds to meet the consumption from other economies.

Moreover, economies with a high RFB exceedance rate imply a high-risk level for water sustainability, although they currently do not possess the largest water withdrawal. For example, economies with the highest exceedance rates are concentrated in the Middle East and Central Asia, including Bahrain, Egypt, Kuwait, the United Arab Emirates, Saudi Arabia, Iraq, Uzbekistan, and Turkmenistan (Figure 3a). In these countries, over 90% of water withdrawal exceeds their RFBs. From the consumption perspective, their exceedance rates are generally lower than those on the territorial side. This is attributed to the significant water scarcity faced by the Middle East and Central Asia, posing a substantial risk to local water resources for production. The potential threat to global water resources diminishes when importing products to meet consumption demands. In contrast, the countries with the highest RFB exceedance volume do not necessarily have the highest exceedance rates. India, China, and the United States, for instance, exhibit exceedance rates of around 60% from both territorial and consumption perspectives.

Our results analyzed the trade flow patterns of embodied RFB exceedances at the regional grid scale and proposed targeted local water management strategies. For example, strengthening the development and transfer of Water-saving equipment and technology to promote the declining of the RFB exceedances in emerging economies and promoting comprehensive responsibility sharing and compensation schemes to alleviate the increasing REF exceedance pressure caused by international trade.