



Sustainability of Virtual Water Trade

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Abstract

- Global virtual water (VW) trade provides a holistic approach to assessing socio-economic aspects and water scarcity conditions of a region. However, the question of the sustainability of such trade is under-explored, given the redistribution of water resources because of climate variability.
- The present study proposes a conceptual framework that highlights the virtual water trade volumes with water availability. An examination of traded water surpluses and deficits in 191 countries and 182 global watersheds is conducted.
- About 45% of countries including major economies are recognized to be accomplishing VW trade unsustainably during 1996-2005. Most European and Asian countries are in a vulnerable state that indicates higher appropriation of water resources than availability influenced by precipitation and evaporation. Similarly, watersheds majorly within western Europe among others, are found to be susceptible to vulnerability. Assessments against future climate indicated that vulnerable watersheds at the present climate tend to become more vulnerable in the future.

Background

- The concept of virtual water explains the volume of water theoretically embedded within goods and moves as hidden water through commodity trades¹⁻³. Since industrialization, anthropogenic interactions with the global water cycle have modified water flows across both space and time⁴⁻⁵. This is not limited to the physical transfer of water stocks but is extendable also to the virtual water flow.
- Importing water-intensive products relieve stress on physical water, especially in arid regions, however, meeting these demands can create pressure on critical hydrological reserves for regions supplying the products.
- Precipitation is the primary source of physical water available to support international trade. On contrary, in general, to relieve stress on real water capitals, VW is imported. However, socio-economic conditions and governmental economic reforms influence these relationships.
- Future water availability assessed from climatic changes in magnitudes of precipitation and evapotranspiration can highlight possible consequences on the sustainable appropriation of water resources when compared to trading practices.

Water Trade and Hydrological Cycle

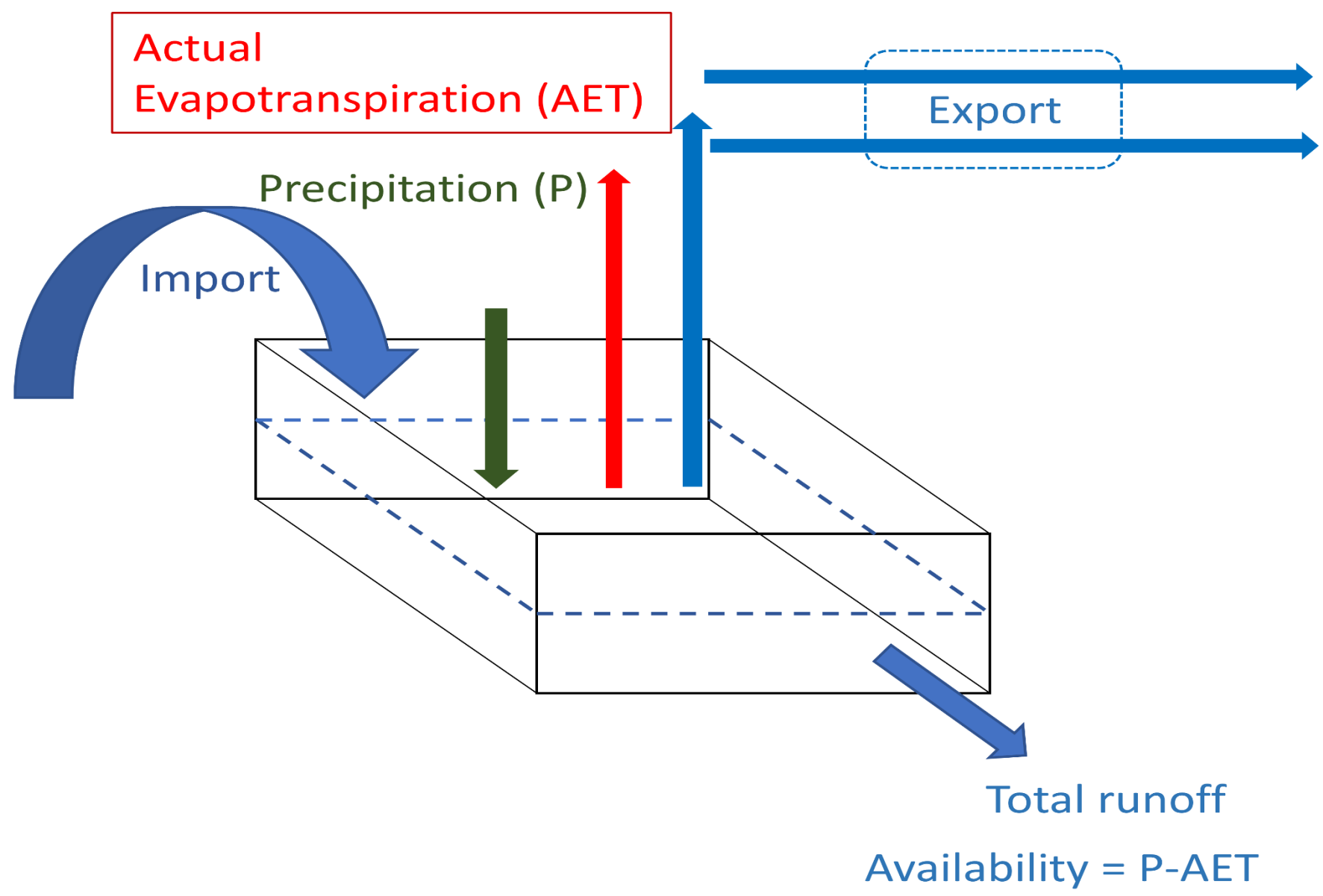


Fig. 1. Conceptual diagram of the relationship of water trade flows with hydrological water fluxes.

Data and Methodology

Hydro-Meteorological Data (ERA5-Land reanalysis: ECMWF)	International VW trade data (Report ⁶)	Spatial data
<ul style="list-style-type: none">PrecipitationPotential EvapotranspirationActual Evapotranspiration	<ul style="list-style-type: none">Blue waterGreen waterGrey water	<ul style="list-style-type: none">WRI major watersheds (FAO-GeoNetwork)Croplands (SEDAC)Pasturelands (SEDAC)Global human footprints (SEDAC)

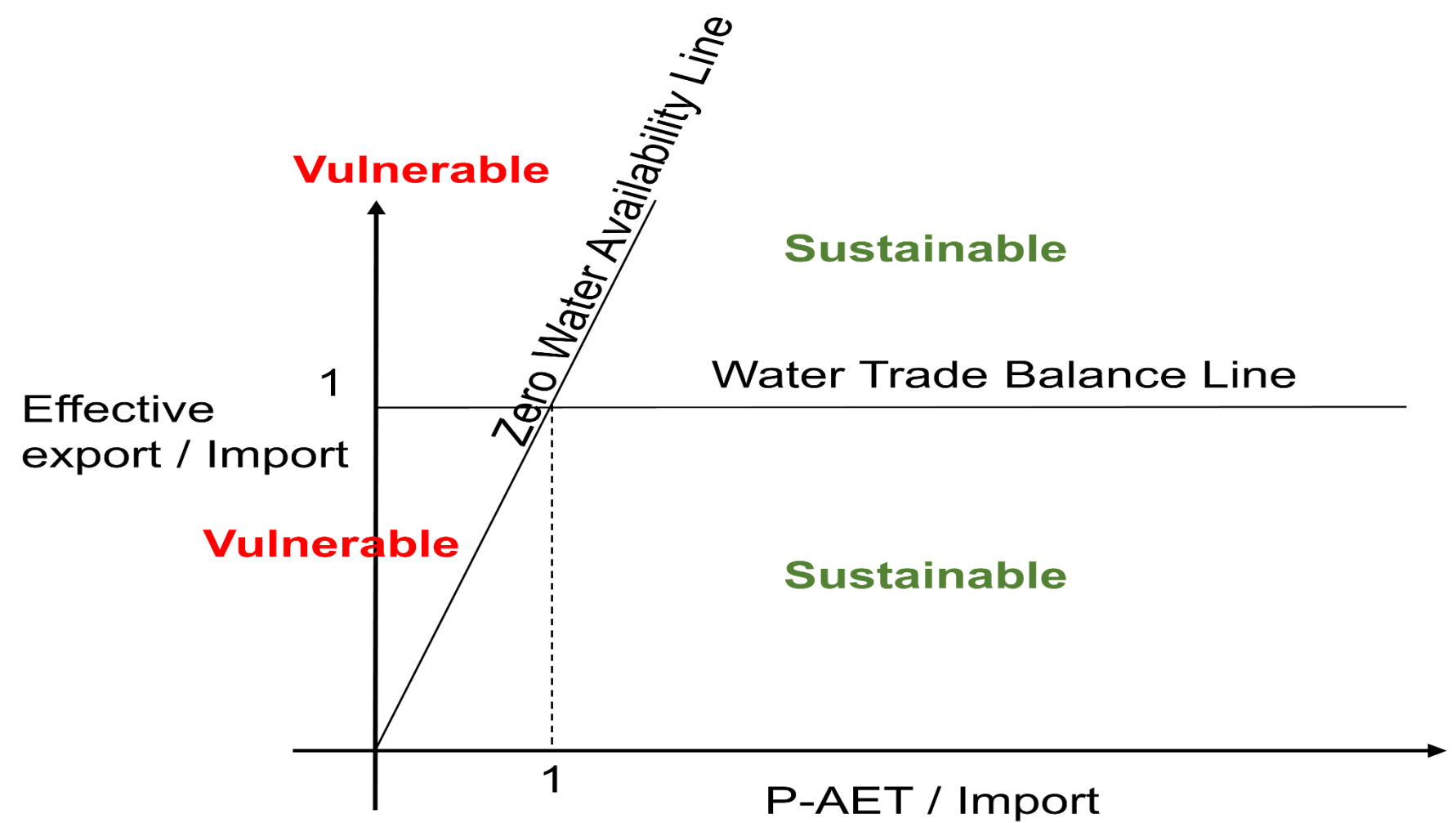


Fig. 2. Conceptual framework of Sustainability-Vulnerable (SV) space

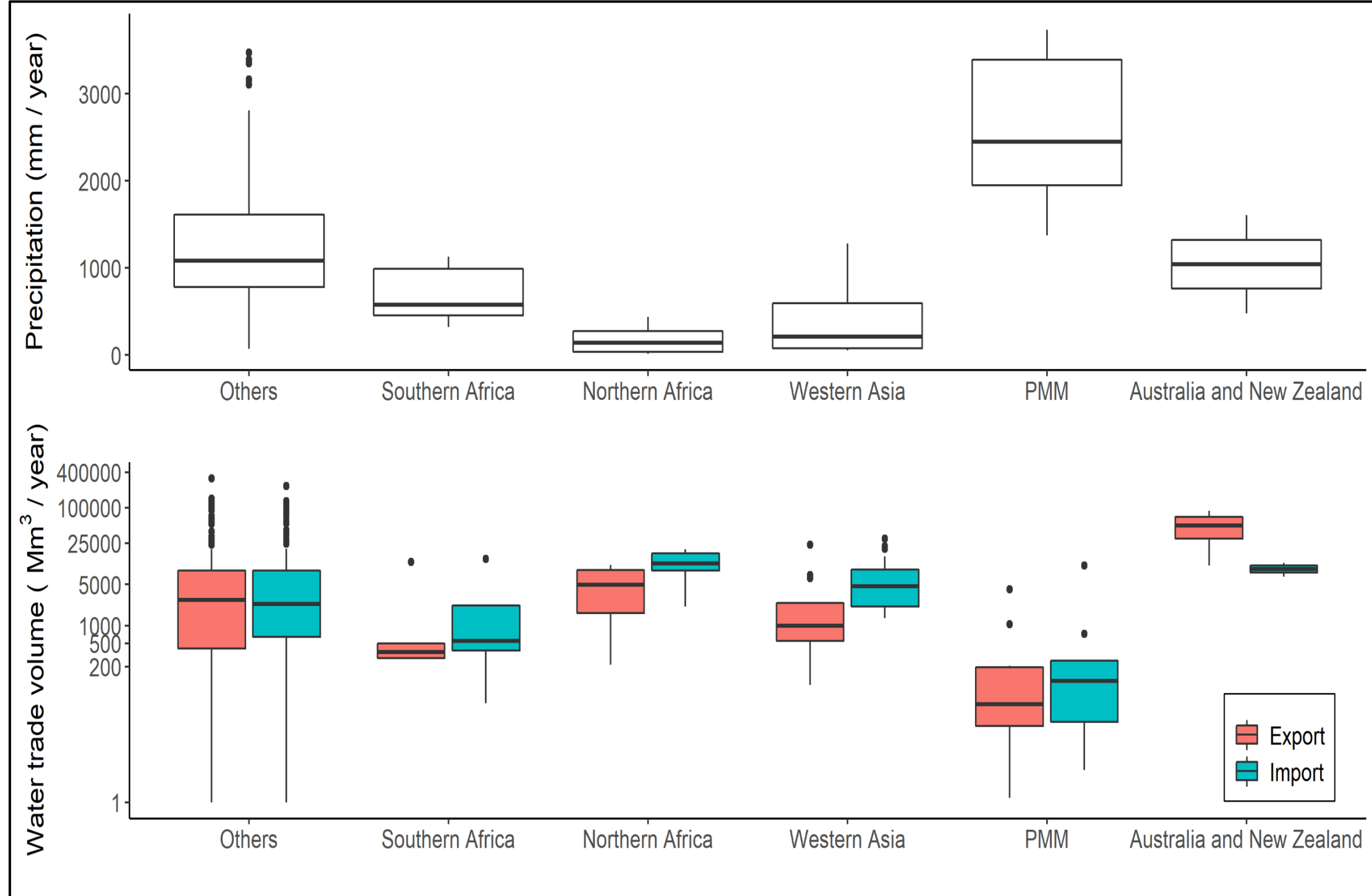


Fig. 3. Distribution of mean annual precipitation across landmasses (1996-2005). 'PMM' is Polynesia-Micronesia-Melanesia

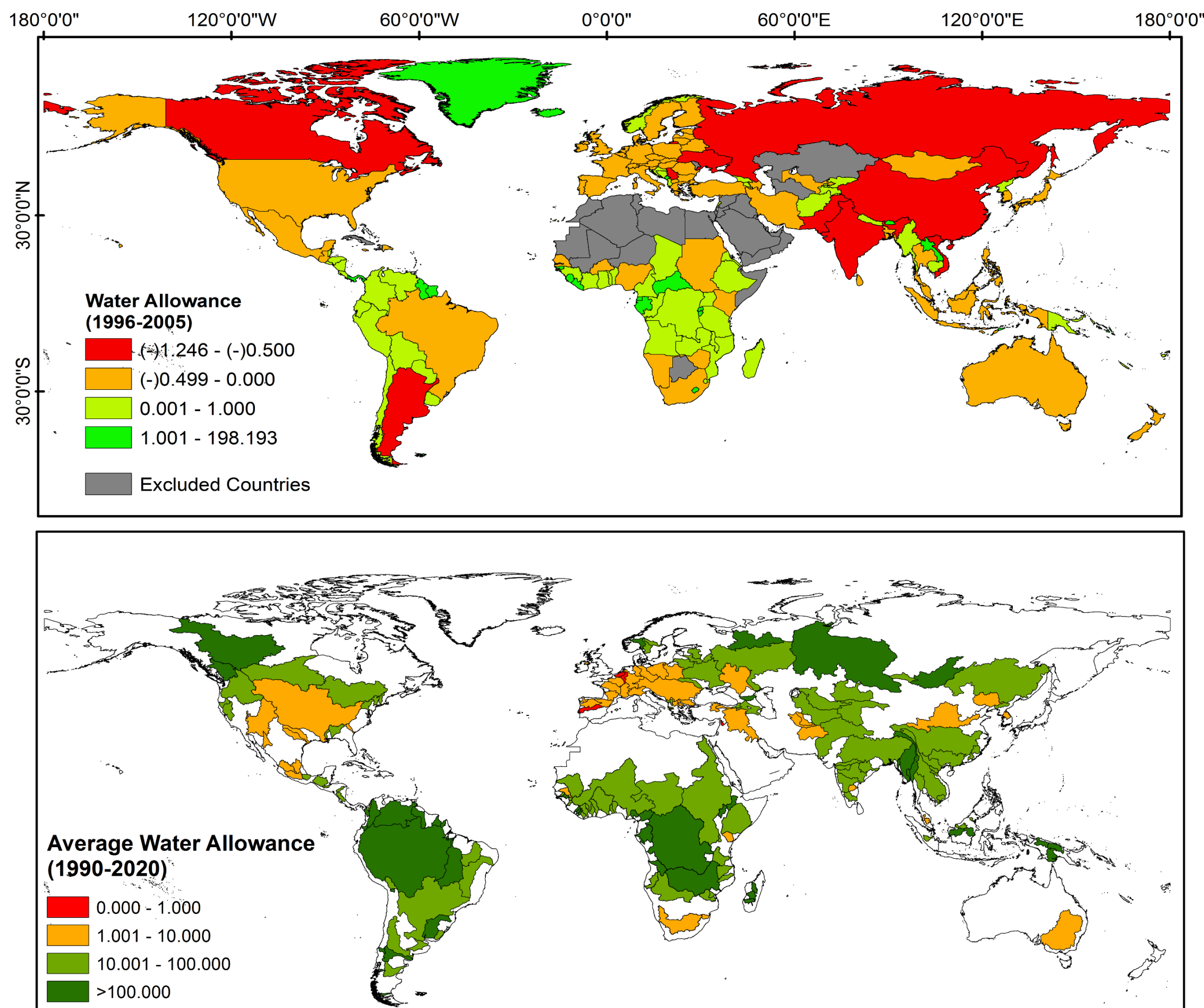


Fig. 4. Spatial distribution of water allowance

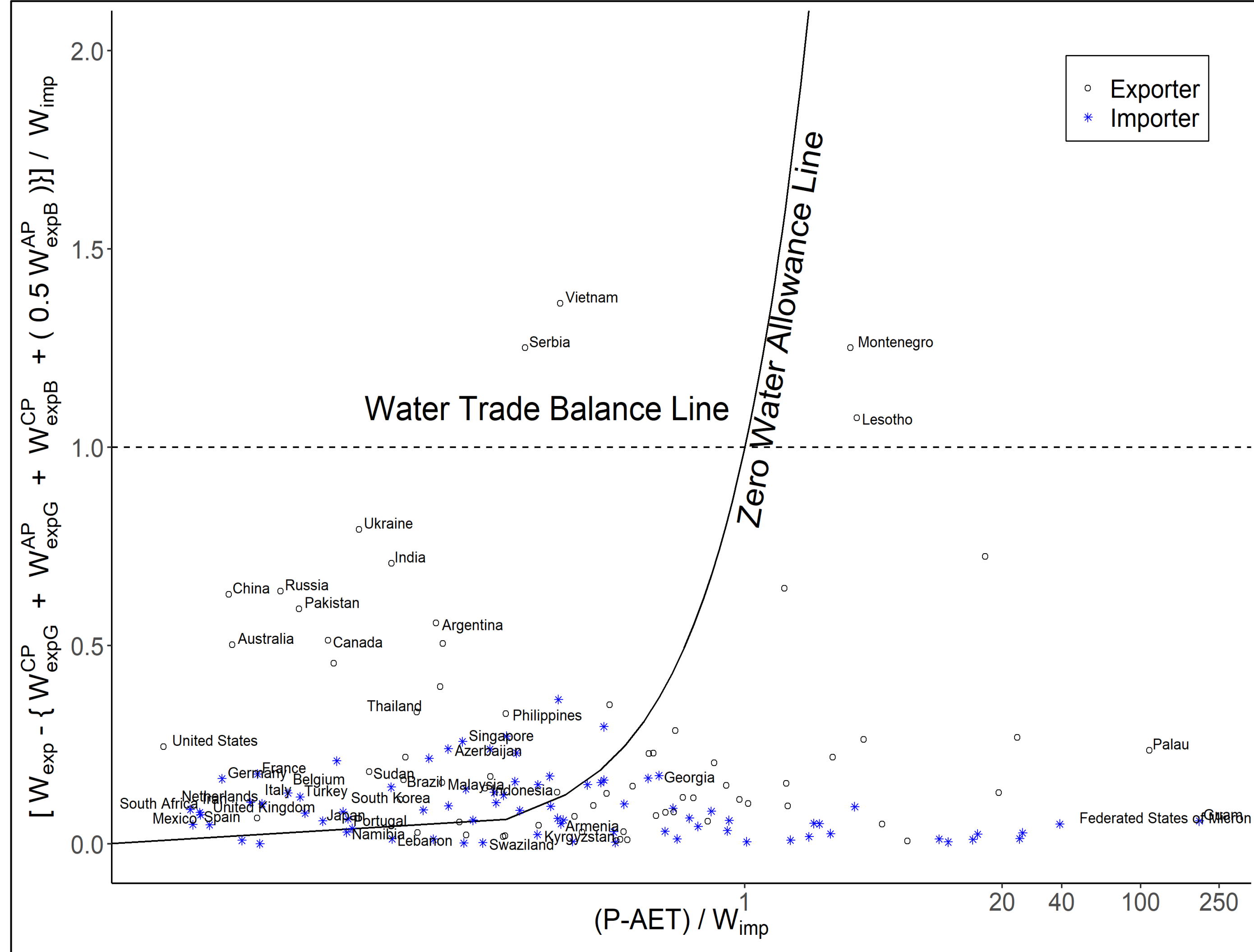


Fig. 5. Scatter plot of countries in SV space

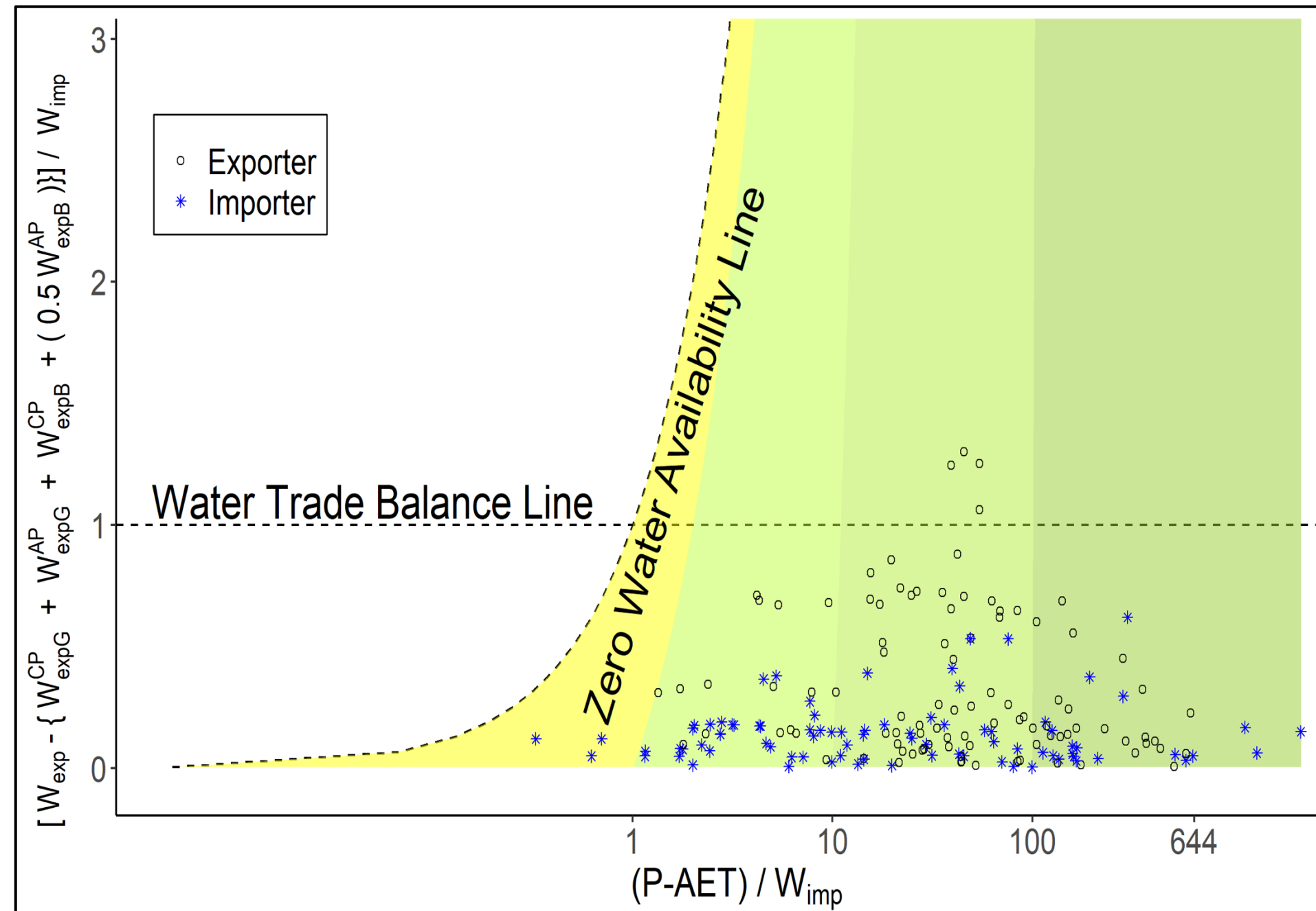


Fig. 6. Scatter plot of watersheds in SV space

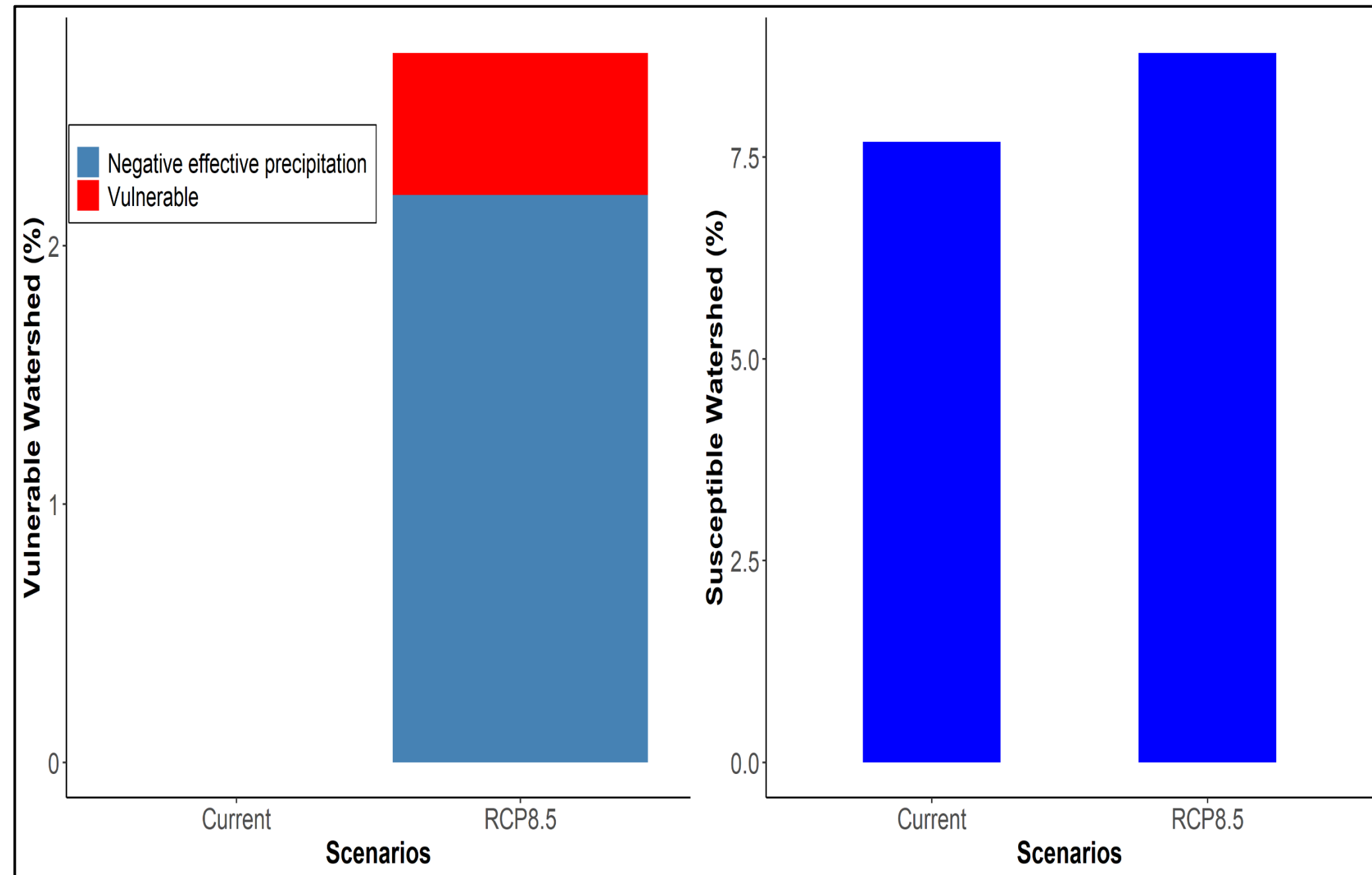


Fig. 7. Percentage of susceptible and vulnerable watersheds

Conclusion

- About one-fifth of the global water footprint is exported across international borders through trade⁷ highlighting dependency on external water.
- Countries, mostly in Europe and Asia are prone to vulnerability pertaining to unsustainable trading practices that possess a danger to domestic water resources.
- Analysis on global watersheds with current and future climate scenarios (RCP8.5) reinforced the idea of adverse implications of inappropriate IVW flows.
- The proposed framework explains the sustainability level of a system towards VW trading by consuming few parameters, unlike the existing methods.

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