SEI Stockholm Environment Institute

Beyond deforestation: water use in global agricultural commodity supply chains

SEI discussion brief
May 2022

Michael Lathuillière (SEI HQ)

Ylva Ran (SEI HQ)

Chris West (SEI York)

Simon Croft (SEI York)

Rafaela Flach (SEI HQ)

Lan Wang-Erlandsson
(Stockholm Resilience Centre)

IMAGE (ABOVE): Oasis of the hinterland © Sérgio Mourão - Encantos do Brasil / Getty

Key Messages

- **Water use and deforestation assessments are complementary in describing sustainable supply chains.**
- **Reducing tropical deforestation in supply chains can reduce risks linked to climate change and water resources.**
- **Top forest-risk commodities imported into the EU rely exclusively on precipitation.**
- **Other commodities, less prone to deforestation, require irrigation and pose water-related risks in agricultural supply chains.**
- **Important global blind spots persist in accounting for water use in supply chains, especially for beef and commodities that depend on tree plantations such as wood, oil palm or rubber.**

Introduction

Interest is increasing within the European Union (EU) policy space to understand the link between tropical deforestation and imports of agricultural commodities. In 2017, the EU27's[a] consumption of agricultural commodities was associated with close to 20% of global tropical deforestation (or 240,000 hectares), according to the newly released Commodity Footprints data (Croft et al., 2021) (see Box 1). Total tropical deforestation associated with the consumption of agricultural commodities in the EU and UK were only second to China, and ahead of India, the US and Japan in 2017 (Pendrill et al., 2020). Addressing this issue at the EU level can encourage other countries to follow, accelerating reductions in greenhouse gas emissions and preventing further loss of biodiversity and ecosystem services.

Since 2018, several initiatives have been proposed acknowledging deforestation in supply chains (European Commission, Directorate General for the Environment., 2018; GRI Taskforce, 2020; MTES, 2018) and, in November 2021, the European Commission drafted a policy proposal to regulate forest-risk commodities (European Commission, 2021). Belgium and Spain joined the seven countries of the Amsterdam Declarations Partnership in 2021, and together with Denmark, France, Germany, Italy, the Netherlands, Norway and the UK, aspire to "achieve sustainable and deforestation-free agricultural commodity supplies" (ADP, 2021). At COP26, countries accounting for 90% of the world's forests affirmed their commitment to "halt and reverse forest loss and land degradation by

a From 1 February 2020, the EU27 refers to the 27 European Union Member States after the United Kingdom left the EU (see Glossary: EU enlargements).

BOX 1: COMMODITY FOOTPRINTS

Commodity Footprints is a new dataset developed at SEI-York (Croft et al., 2021). The results were generated using the Input-Output Trade Analysis (IOTA) framework. IOTA is a hybrid multi-regional input-output (MRIO) model, combining national-level data on production and trade of individual commodities (from the FAO) with a financial representation of the global economy (the EXIOBASE MRIO). This provides information by country and commodity at the production end, along with the full supply chain perspective afforded by MRIO approaches. Results capture not just direct trade flows from production to consumption, but also indirect flows and embedded demands, meaning that a commodity has been either combined with or used to produce other products (e.g., palm oil used in shampoo formulations or cattle fed with soybean cake).

This framework allows the addition of environmental indicators by converting commodity mass flows into embedded trade flows of environmental impacts and risks. Country- and commodity-specific intensities across a range of environmental metrics result in a set of consumption-driven indicators associated with localized production of primary commodities.

(continued on next page)

2030"(UK COP26, 2021, p. 26), despite similar commitments in the New York Declaration on Forests (UN, 2014) having failed to meet their 2020 objectives.

Efforts to move towards zero deforestation in the supply chains of agricultural commodities such as soy, maize, palm oil, cocoa, rubber and beef imply a rapid decrease of agricultural expansion in tropical frontiers and a transition towards more intensive production. Further agricultural intensification – increasing production by increasing yields – requires additional resources such as water and fertilizer, but to be more sustainable, also needs to observe other environmental and socio-economic aspects, such as soil, water and forest stewardship, while supporting livelihoods and promoting animal welfare.

Water plays a key role in qualifying whether agricultural intensification can be considered environmentally sustainable. Since 2012, "water crises" have been consistently part of the top five global risks of concern, according to the World Economic Forum (WEF, 2021).[b] The overexploitation or contamination of water resources can present a significant risk to countries, communities and industries, but also to ecosystems. About 40% of the water used by the EU economy is sourced from river basins located outside its borders, which experience varying levels of water scarcity throughout the year (Ercin et al., 2019). Droughts can considerably affect agricultural yields, particularly in regions where production is vulnerable to precipitation variability, as recently experienced in South America (Laje et al., 2021).

The current push for greater scrutiny and due diligence on deforestation in supply chains, presents an opportunity to expand beyond a single deforestation metric and adopt a more comprehensive definition of environmentally sustainable supply chains for the EU. Overlooking water use for agricultural commodities may shift environmental burdens from regions with high deforestation rates to regions with high water scarcity. In this discussion brief, we explore tropical deforestation and water use in supply chains to highlight the connections between land and water use in agricultural commodity production and describe potential blind spots with respect to water use in supply chains.

Forests and water resources are regionally connected

Deforestation inevitably affects the water cycle. Trees use soil moisture and return water vapour to the atmosphere, which supply downwind precipitation and moderate local temperatures. This means that forests not only store carbon, but also play a role in sustaining regional climate and water cycles (Ellison et al., 2017).

The replacement of tropical forests by pasture and cropland in South America can increase local temperatures by up to 2.5°C compared to forested areas, without considering the effects of global climate change (Silvério et al., 2015). In the Amazon and Cerrado[c] biomes, an average tree can return 200–450 litres per day of water[d] to the atmosphere from vapour released during photosynthesis (transpiration), as well as evaporation from soil and tree surfaces. This combined water vapour supply feeds what's called a "flying river"[e] that generates rainfall downwind from its source (Marengo, 2006; Pearce, 2021) and constitutes a critical ecosystem service for supporting forest resilience and agricultural production (Keys et al., 2016). A combination of local warming and

b "Water crises" is part of the World Economic Forum's "Natural Resource Crises" category in 2021.
c The Cerrado is Brazil's vast savanna biome whose deforestation rates are similar to the Amazon biome (Strassburg et al., 2017).
d Own estimate.
e "Flying rivers" are atmospheric watercourses formed by prevailing winds that carry moisture supplied upwind by forests and ecosystems through evapotranspiration to deliver rainfall downwind.

(continued from previous page)

Results are available for 160 crops, plus beef and timber, across 200 countries for the 2005–2017 period; consumption linkages are made for 44 consuming countries and five "rest of world" regions (according to MRIO classifications). Land use (area harvested), water use (for green, blue and scarcity-weighted blue water[f]) and biodiversity (as predicted species loss and species richness-weighted area[g]) extensions are available for all crop commodities. Additionally, tropical deforestation and related carbon dioxide emissions metrics (including or excluding peat drainage) are available for all featured commodities. For more information, see details on the methodology.

f Scarcity-weighted blue water is the volume of freshwater (blue water) multiplied by a blue water scarcity factor that is based on the amount of water remaining in a river basin after human and ecosystem demands have been met (Boulay et al., 2018).

g Species richness-weighted area is the area of crop produced multiplied by the number of mammal, bird and amphibian species present in that same area (https://commodityfootprints.earth/).

reduced precipitation can affect yields and push farmers to opt for irrigation to secure future agricultural production.

Agriculture, forestry and livestock production rely on both "blue" (as surface and groundwater) and "green" water (as soil moisture exclusively sourced from precipitation) (Falkenmark & Rockström, 2006). Blue water use for irrigation or livestock competes with other domestic and industrial uses in a river basin and its overexploitation may affect both communities and aquatic ecosystems. The availability of green water depends on regional climate and precipitation, itself regenerated by the soil moisture used by forest and agro-ecosystems. By expanding agriculture into previously forested land, farmers appropriate green water resources for food production, but can also appropriate blue water resources for irrigation purposes.

This close connection between land and water strengthens the case for deforestation-free supply chains. Moving towards zero deforestation in agricultural commodity supply chains can provide multiple interconnected benefits, including biodiversity conservation, reducing regional and global climate risks, and minimizing the risks linked to water scarcity. These added benefits will, however, go unnoticed if not considered explicitly. Prioritizing deforestation and related carbon emissions as the only risks in supply chains will miss important water-related risks to production with effects on terrestrial and aquatic ecosystems.

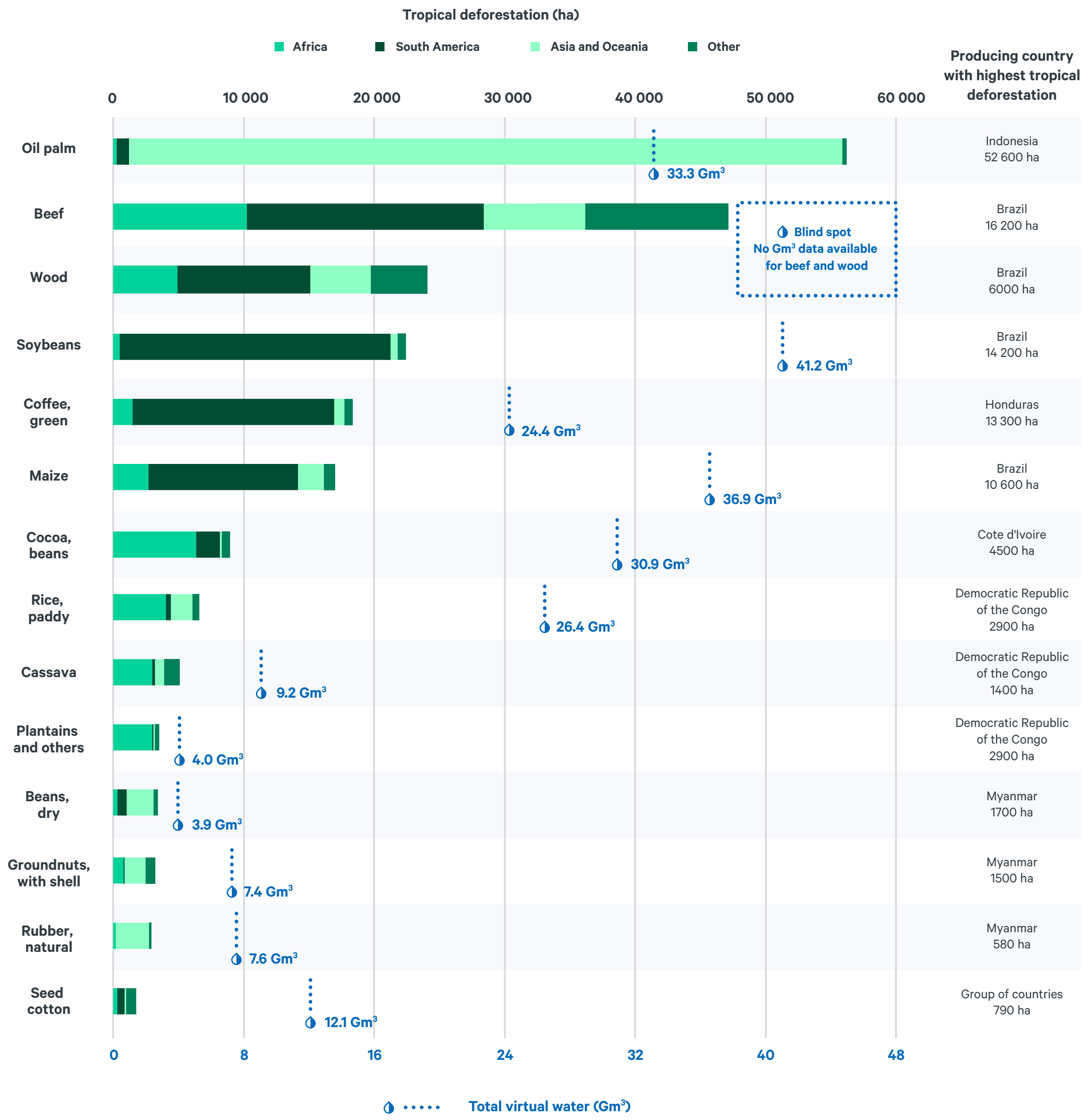
Green and blue water uses in the EU's agricultural commodity supply chains

The newly released Commodity Footprints (Croft et al., 2021) dataset brings together global commodity production and trade statistics with water (Tamea et al., 2021), tropical deforestation and associated carbon emissions (Pendrill et al., 2020), cropland area and biodiversity metrics to allow for a combined assessment of agricultural commodity consumption (see Box 1). In 2017, the most recent year available in the dataset, the top agricultural commodities linked to consumption in the EU and associated with tropical deforestation were oil palm, beef, wood and soy products, followed by coffee, maize, cocoa and others such as rubber (Figure 1).

Soy, maize, oil palm, cocoa, rice and coffee also consume large volumes of freshwater (Figure 1). These volumes are linked to a range of water use for each agricultural commodity's needs and the unique climate in the countries of production, for instance: cocoa from 14,038 cubic metres per ton of crop (m^3/ton) in Côte d'Ivoire to 27,924 m^3/ton in Cameroon; soybean from 2,094 m^3/ton in Argentina to 2,492 m^3/ton in Paraguay; coffee from 6,260 m^3/ton in Vietnam to 28,267 m^3/ton in Côte d'Ivoire; maize from 1,244 m^3/ton in Mexico to 4,053 m^3/ton in the Democratic Republic of Congo (average of 1996–2005 period) (Mekonnen & Hoekstra, 2011). This wide variability of water use highlights how changes in production practices could improve water productivity, particularly across commodities sourced in Africa (Rockström and Barron, 2007).

As a resource use indicator, water use in supply chains (Figure 1) can only show the total volume of water linked to consumption with the assumption that all water is equal. A corresponding impact indicator can estimate the impacts of water use on water scarcity (Boulay et al., 2018). In relative terms, both indicators provide a benchmark for water resource use per commodity – similar to the amount of commodity produced per drop of water – and impact to water scarcity per commodity (Figure 2). The commodities associated with the largest tropical deforestation (Figure 1) rely almost exclusively on green water resources. This reliance on green water suggests that production can

Figure 1: Agricultural commodities linked to EU27 consumption in 2017 that were associated with the most tropical deforestation in hectares (ha), alongside their total virtual water volumes in giga cubic metres (Gm³).

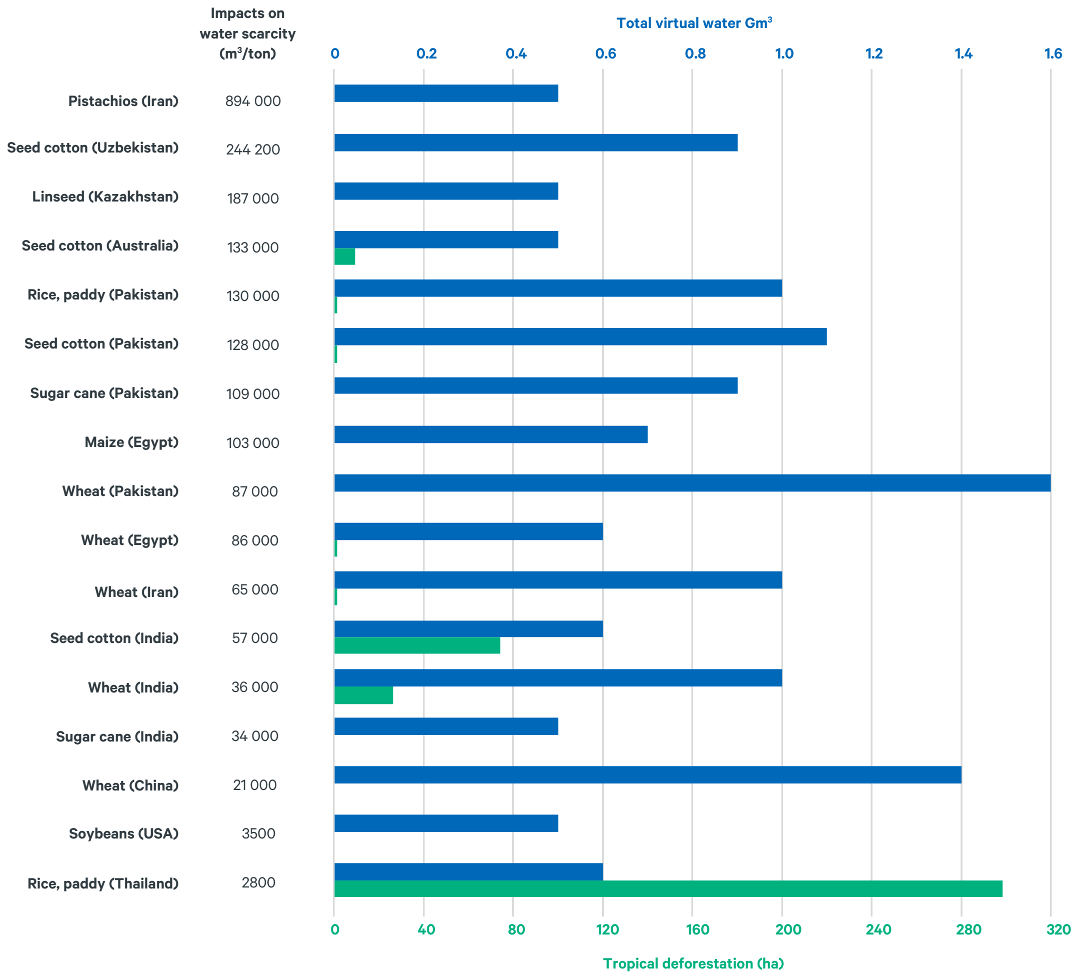


Source: *https://commodityfootprints.earth/*

be affected by regional climate change and variability in precipitation, which can be exacerbated by further deforestation (see Section: "Forests and water resources are regionally connected").

However, many commodities consumed in the EU do require irrigation (as blue water). They are not necessarily associated with tropical deforestation, but have impacts of their own in distant river basins, their populations and aquatic ecosystems. Pistachios, cotton, linseed, rice, sugar cane and maize consumed in the EU carry the largest impacts to water scarcity in their countries of production in the Middle East and Asia (Figure 2). Only a few commodities in 2017 were both associated with deforestation and water scarcity, such as rice produced in Thailand. Soybean was one commodity that was either most associated with deforestation in Brazil (Figure 1), or with irrigation in the US (Figure 2), showing a possible shift in environmental burden of imports based on the country supplying the commodity.

Figure 2: Largest volumes of virtual blue water trade in giga cubic metres (Gm^3) for agricultural commodities linked to EU27 consumption in 2017 and their respective associated tropical deforestation in hectares (ha) in producing countries. Values are ranked based on their impacts on water scarcity in cubic meters per ton (m^3/ton) according to water footprint values (Mekonnen and Hoekstra, 2011) and country-specific factors (Boulay et al., 2018).



Source: https://commodityfootprints.earth/

Global blind spots for water use in supply chains

Despite the above data, blind spots persist in the amount of water associated with commodity production and consumption either due to lack of global scalability, or to methodological challenges. This is the case for either beef or wood products for which there are no updated global estimates (see "Blind spot" in Figure 1). First, the relationship between water use and crop yield can help predict water use for traded agricultural crops (Tamea et al., 2021), but no equivalent assumptions can be made for beef and other livestock and their products. Global assessments of water use for beef are challenging to determine due to the wide variety of production systems, environments and breeds. The Livestock Environmental Assessment and Performance partnership (FAO-LEAP) only recently published guidelines to estimate water use for livestock and its supply chains (FAO, 2019) and widespread application will take time.

Secondly, a framework for estimating water use for wood products remains a methodological challenge. Global consumption of roundwood in the 2001–2010 period was associated with 961 giga cubic metres per year (Gm^3/y) of water use (up 25% from

BOX 2: TRASEH2O IN BRAZIL

Since 2016, the Trase tool has provided assessment of deforestation risk in the global supply chains of soy, beef and palm oil in Brazil, Paraguay, Argentina and Indonesia by combining commodity supply chain information with sub-national deforestation estimates. The result is a spatially explicit commodity supply chain linking a location of production (e.g., a municipality in Brazil) to a country of import. Deforestation and resulting greenhouse gas emissions are then combined with these supply chains to associate imports with deforestation.

Using the same supply chain maps, the TraseH2O project adds agricultural water use onto the Trase platform. In its first stage, the project will focus on water use for both soybean and cattle in Brazil to link it to imports into China and the EU. The project will fill important knowledge gaps on calculating water use for cattle, as well as advance impact assessments linking deforestation to moisture recycling with the goal of highlighting trade-offs in supply chains of soy and beef commodities.

An initial assessment for the Brazilian state of Mato Grosso showed half of the water use for cattle was due to evaporation of farm impoundments, which are typically constructed to provide drinking water (Lathuillière et al., 2019). Cattle density in Brazil is generally low and some suggest that increasing cattle population on existing pastureland could prevent further deforestation (Strassburg et al., 2014). This proposal, however, would also require expanding water use for a larger herd, with potential for conflict between upstream (e.g., agriculture) and downstream uses (e.g., hydroelectric production, aquatic ecosystem health) and sustainability targets.

These land and water use trade-offs and their representation in soy and beef supply chains are at the heart of the TraseH2O project.

the 1961–1970 period), which was predominantly green water (Schyns et al., 2017). Such estimates for commodities sourced from tree plantations (e.g. wood products, palm or rubber), rely on calculations of water use for tree development, but also need to consider that these systems also provide additional ecosystem services. Furthermore, the mapping of plantations and management practices across the globe, as well as their relationship to deforestation and water use, also remains a challenge (Manoli et al., 2018).

Opportunities and challenges

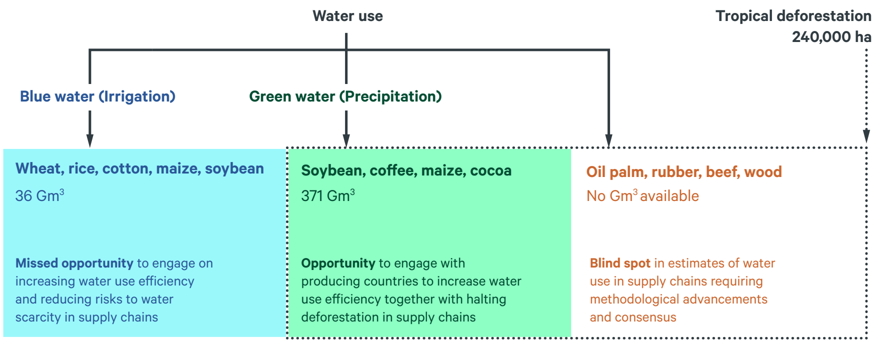
In the context of due diligence legislation on deforestation in supply chains, there is an opportunity to widen the definition of environmentally sustainable supply chains beyond deforestation to also include water use. The EU and its Member States have an opportunity to engage with producing countries to both halt deforestation and promote efficient water use for agricultural production for a set of key commodities, particularly cocoa and coffee (see Figure 3).

Current EU consumption of forest-risk commodities relies on green water resources, but a handful of commodities sourced in the Middle East and Asia are linked to additional water risks. Without this additional visibility, there is a potential risk of shifting some environmental burdens from deforestation frontiers to water-scarce regions.

Blind spots in water use for beef and wood products are a major challenge to advance on the sustainable supply chain agenda. Cattle require both blue water through drinking, but also green water through feed. Wood products and other commodities that rely on tree plantations (oil palm, rubber) use water over a longer period of time compared to annual crops, but also sequester carbon and provide other ecosystem services, and so present distinct trade-offs in the landscape. Further research should focus on advancing accounting measures and expanding methods to calculate water use for cattle (see Box 2), as well as a wider consensus around water use for wood products and commodities from tree plantations.

Going beyond deforestation by including water use in supply chains is a logical step to highlight trade-offs in supply chain decisions. Existing datasets can already provide some information on deforestation, greenhouse gas emissions and water use. Future steps should also include developing a global understanding of water quality impacts in supply chains, which inevitably will require an understanding of fertilizer trade and use for food production.

Figure 3: Visual summary of key messages presented in this Discussion Brief, including opportunities to engage, and blind spots in the data. Values for tropical deforestation and water use are those presented in the Discussion Brief for agricultural commodities imported into the EU27 in 2017.



Source: https://commodityfootprints.earth/

ACKNOWLEDGEMENTS

This discussion brief was produced as part of the TraseH2O project, funded by Formas – a Swedish Research Council for Sustainable Development (project 2020-00688). Development of the Commodity Footprints dashboard was supported by the UK Department for Environment, Food & Rural Affairs (Defra), the UK Research and Innovation Global Challenges Research Fund through the Trade, Development and the Environment Hub project (project ES/S008160/1), and the Trase Project.

References

ADP. (2021). Amsterdam Declarations Partnership Statement of Ambition 2025. Amsterdam Declarations Partnership. https://ad-partnership.org/wp-content/uploads/2021/02/AD-Partnership-Ambition-Statement-2025.pdf

Boulay, A.-M., Bare, J., Benini, L., Berger, M., Lathuillière, M. J., Manzardo, A., Margni, M., Motoshita, M., Núñez, M., Pastor, A. V., Ridoutt, B., Oki, T., Worbe, S., & Pfister, S. (2018). The WULCA consensus characterization model for water scarcity footprints: Assessing impacts of water consumption based on available water remaining (AWARE). The International Journal of Life Cycle Assessment, 23(2), 368–378. https://doi.org/10.1007/s11367-017-1333-8

Croft, S., West, C., Harris, M., Green, J., Molotoks, A., Harris, V., & Way, L. (2021). JNCC Report Technical documentation for an experimental statistic estimating the global environmental impacts of UK consumption (JNCC Report No. 695). JNCC. https://hub.jncc.gov.uk/assets/91efc19d-f675-426f-9333-ed0195cc729d

Ellison, D., Morris, C. E., Locatelli, B., Sheil, D., Cohen, J., Murdiyarso, D., Gutierrez, V., Noordwijk, M. van, Creed, I. F., Pokorny, J., Gaveau, D., Spracklen, D. V., Tobella, A. B., Ilstedt, U., Teuling, A. J., Gebrehiwot, S. G., Sands, D. C., Muys, B., Verbist, B., … Sullivan, C. A. (2017). Trees, forests and water: Cool insights for a hot world. Global Environmental Change, 43, 51–61. https://doi.org/10.1016/j.gloenvcha.2017.01.002

Ercin, E., Chico, D., & Chapagain, A. K. (2019). Vulnerabilities of the European Union's Economy to Hydrological Extremes Outside its Borders. Atmosphere, 10(10), 593. https://doi.org/10.3390/atmos10100593

European Commission. (2021). Proposal for a Regulation of the European Parliament and of the Council on the making available on the Union market as well as export from the Union of certain commodities and products associated with deforestation and forest degradation and repealing Reg (COM(2021) 706). European Commission. https://ec.europa.eu/environment/publications/proposal-regulation-deforestation-free-products_en

European Commission, Directorate General for the Environment. (2018). Feasibility study on options to step up EU action against deforestation: PART I, background analysis, scale and trends of global deforestation and assessment of EU contribution and PART II, a potential EU initiative on deforestation, possible interventions. Publications Office. https://data.europa.eu/doi/10.2779/97793

Falkenmark, M., & Rockström, J. (2006). The New Blue and Green Water Paradigm: Breaking New Ground for Water Resources Planning and Management. Journal of Water Resources Planning and Management, 132(3), 129–132. https://doi.org/10.1061/(ASCE)0733-9496(2006)132:3(129)

FAO. (2019). Water use in livestock production systems and supply chains: Guidelines for assessment, version 1. FAO. https://www.fao.org/publications/card/en/c/CA5685EN/

GRI Taskforce. (2020). Final Recommendation Report. Global Resource Initiative. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/876465/gri-taskforce-executive-summary.pdf

Keys, P. W., Wang-Erlandsson, L., & Gordon, L. J. (2016). Revealing Invisible Water: Moisture Recycling as an Ecosystem Service. PLOS ONE, 11(3), e0151993. https://doi.org/10.1371/journal.pone.0151993

Laje, D., Faiola, A., & Herrero, A. V. (2021, September 24). Spiking Energy Bills, Showers Once a Week. In South America, the Climate Future Has Arrived. The Washington Post. https://www.washingtonpost.com/world/2021/09/24/argentina-brazil-south-america-drought/

Lathuillière, M. J., Solvik, K., Macedo, M. N., Graesser, J., Miranda, E. J., Couto, E. G., & Johnson, M. S. (2019). Cattle production in Southern Amazonia: Implications for land and water management. Environmental Research Letters, 14(11), 114025. https://doi.org/10.1088/1748-9326/ab30a7

Manoli, G., Meijide, A., Huth, N., Knohl, A., Kosugi, Y., Burlando, P., Ghazoul, J., & Fatichi, S. (2018). Ecohydrological changes after tropical forest conversion to oil palm. Environmental Research Letters, 13(6), 064035. https://doi.org/10.1088/1748-9326/aac54e

Marengo, J. (2006). On the hydrological cycle of the Amazon Basin: A historical review and current state-of-the-art. Revista Brasileira de Meteorologia, 21(3), 1–19.

Mekonnen, M. M., & Hoekstra, A. Y. (2011). The green, blue and grey water footprint of crops and derived crop products. Hydrology and Earth System Sciences, 15(5), 1577–1600. https://doi.org/10.5194/hess-15-1577-2011

MTES. (2018). Stratégie nationale de lutte contre la déforestation importée 2018-2030. Ministère de la Transition Écologique et Solidaire. https://www.ecologique-solidaire.gouv.fr/sites/default/files/2018.11.14_SNDI_0.pdf

Pearce, F. (2021). Weather Makers: Forests Supply the World with Rain. A controversial Russian theory claims forests don't just make rain—They make wind [Data set]. In Science. https://doi.org/10.1126/science.abd3856

Pendrill, F., Persson, U. M., & Kastner, T. (2020). Deforestation risk embodied in production and consumption of agricultural and forestry commodities 2005-2017 (1.0) [Data set]. Zenodo. https://doi.org/10.5281/ZENODO.4250532

Schyns, J. F., Booij, M. J., & Hoekstra, A. Y. (2017). The water footprint of wood for lumber, pulp, paper, fuel and firewood. Advances in Water Resources, 107, 490–501. https://doi.org/10.1016/j.advwatres.2017.05.013

Silvério, D. V., Brando, P. M., Macedo, M. N., Beck, P. S. A., Bustamante, M., & Coe, M. T. (2015). Agricultural expansion dominates climate changes in southeastern Amazonia: The overlooked non-GHG forcing. Environmental Research Letters, 10(10), 104015. https://doi.org/10.1088/1748-9326/10/10/104015

Strassburg, B. B. N., Brooks, T., Feltran-Barbieri, R., Iribarrem, A., Crouzeilles, R., Loyola, R., Latawiec, A. E., Oliveira Filho, F. J. B., Scaramuzza, C. A. de M., Scarano, F. R., Soares-Filho, B., & Balmford, A. (2017). Moment of truth for the Cerrado hotspot. Nature Ecology & Evolution, 1(4), 0099. https://doi.org/10.1038/s41559-017-0099

Strassburg, B. B. N., Latawiec, A. E., Barioni, L. G., Nobre, C. A., da Silva, V. P., Valentim, J. F., Vianna, M., & Assad, E. D. (2014). When enough should be enough: Improving the use of current agricultural lands could meet production demands and spare natural habitats in Brazil. Global Environmental Change, 28, 84–97. https://doi.org/10.1016/j.gloenvcha.2014.06.001

Tamea, S., Tuninetti, M., Soligno, I., & Laio, F. (2021). Virtual water trade and water footprint of agricultural goods: The 1961–2016 CWASI database. Earth System Science Data, 13(5), 2025–2051. https://doi.org/10.5194/essd-13-2025-2021

UK COP26. (2021). Glasgow Leaders' Declaration on Forests and Land Use. UK COP26. https://ukcop26.org/glasgow-leaders-declaration-on-forests-and-land-use

UN. (2014). New York Declaration on Forests: Declaration and Action Agenda. United Nations. https://www.undp.org/content/dam/undp/library/Environment and Energy/Forests/New York Declaration on Forests_DAA.pdf

WEF. (2021). The Global Risks Report 2021 16th Edition (p. 97). World Economic Forum. http://www3.weforum.org/docs/WEF_The_Global_Risks_Report_2021.pdf

Published by
Stockholm Environment Institute
Linnégatan 87D, Box 24218
104 51 Stockholm, Sweden
Tel: +46 8 30 80 44

https://doi.org/10.51414/sei2022.005

Author contact
michael.lathuilliere@sei.org

Visit us: sei.org
Twitter: @SEIresearch
@SEIclimate