



Universiteit
Leiden
The Netherlands

Assessing global regionalized impacts of eutrophication on freshwater fish biodiversity

Zhou, J.

Citation

Zhou, J. (2024, January 30). *Assessing global regionalized impacts of eutrophication on freshwater fish biodiversity*. Retrieved from <https://hdl.handle.net/1887/3715136>

Version: Publisher's Version

License: [Licence agreement concerning inclusion of doctoral thesis in the Institutional Repository of the University of Leiden](#)

Downloaded from: <https://hdl.handle.net/1887/3715136>

Note: To cite this publication please use the final published version (if applicable).

References

- Abell, R., Thieme, M.L., Revenga, C., Bryer, M., Kottelat, M., Bogutskaya, N., Coad, B., Mandrak, N., Balderas, S.C., Bussing, W., Stiassny, M.L.J., Skelton, P., Allen, G.R., Unmack, P., Naseka, A., Ng, R., Sindorf, N., Robertson, J., Armijo, E., Higgins, J. V., Heibel, T.J., Wikramanayake, E., Olson, D., López, H.L., Reis, R.E., Lundberg, J.G., Sabaj Pérez, M.H., Petry, P., 2008. Freshwater Ecoregions of the World: A New Map of Biogeographic Units for Freshwater Biodiversity Conservation. *Bioscience* 58, 403–414.
- Adam, J.C., Lettenmaier, D.P., 2008. Application of New Precipitation and Reconstructed Streamflow Products to Streamflow Trend Attribution in Northern Eurasia. *J Clim* 21, 1807–1828.
- Akhtar, N., Syakir Ishak, M.I., Bhawani, S.A., Umar, K., 2021. Various natural and anthropogenic factors responsible for water quality degradation: A review. *Water (Basel)* 13, 2660.
- Alexander, R.B., Elliott, A.H., Shankar, U., McBride, G.B., 2002. Estimating the sources and transport of nutrients in the Waikato River Basin, New Zealand. *Water Resour Res* 38, 4-1-4–23.
- Alexander, R.B., Smith, R.A., Schwarz, G.E., 2004. Estimates of diffuse phosphorus sources in surface waters of the United States using a spatially referenced watershed model. *Water Science and Technology* 49, 1–10.
- Ansari, A.A., Gill, S.S., Khan, F.A., 2011. Eutrophication: threat to aquatic ecosystems. *Eutrophication: causes, consequences and control* 143–170.
- Arheimer, B., Pimentel, R., Isberg, K., Crochemore, L., Andersson, J.C.M., Hasan, A., Pineda, L., 2020. Global catchment modelling using World-Wide HYPE (WWH), open data, and stepwise parameter estimation. *Hydrol Earth Syst Sci* 24, 535–559.
- Arya, S., 2021. Freshwater Biodiversity and Conservation Challenges: A Review. *IJBI* 3.
- Aulenbach, B.T., Buxton, H.T., Battaglin, W.A., Coupe, R.H., 2007. Streamflow and nutrient fluxes of the Mississippi-Atchafalaya River Basin and subbasins for the period of record through 2005. US Geological Survey.
- Azevedo, Ligia B., van Zelm, R., Elshout, P.M.F., Hendriks, A.J., Leuven, R.S.E.W., Struijs, J., de Zwart, D., Huijbregts, M.A.J., 2013. Species richness-phosphorus relationships for lakes and streams worldwide. *Global ecology and biogeography* 22, 1304–1314.
- Azevedo, L B, van Zelm, R., Hendriks, A.J., Bobbink, R., Huijbregts, M.A.J., 2013. Quantitative effects of soil pH on plant species richness: a global assessment. *Environ Pollut* 174, 10–15.

- Azevedo, L.B., Verones, F., Henderson, A.D., van Zelm, R., Jolliet, O., Scherer, L., Huijbregts, M.A.J., 2020. Chapter 8. Freshwater eutrophication. In: LC-IMPACT Version 1.0.
- Barbarossa, V., Bosmans, J.H.C., King, H., Bierkens, M.F.P., Huijbregts, M.A.J., Schipper, A.M., 2021. Threats of global warming to the world's freshwater fishes. *Nat Commun* 12, 1–10.
- Barbarossa, V., Schmitt, R.J.P., Huijbregts, M.A.J., Zarfl, C., King, H., Schipper, A.M., 2020. Impacts of current and future large dams on the geographic range connectivity of freshwater fish worldwide. *Proceedings of the National Academy of Sciences - PNAS* 117, 3648–3655.
- Bare, J., 2011. TRACI 2.0: the tool for the reduction and assessment of chemical and other environmental impacts 2.0. *Clean Technol Environ Policy* 13, 687–696.
- Bare, J., Young, D., Qam, S., Hopton, M., Chief, S., 2012. Tool for the Reduction and Assessment of Chemical and other Environmental Impacts (TRACI). Washington, DC: US Environmental Protection Agency.
- Bare, J.C., 2002. TRACI: The tool for the reduction and assessment of chemical and other environmental impacts. *J Ind Ecol* 6, 49–78.
- Behrendt, H., Opitz, D., 1999. Retention of nutrients in river systems: dependence on specific runoff and hydraulic load. In: *Man and River Systems*. Springer Netherlands, Dordrecht, pp. 111–122.
- Beusen, A.H.W., Bouwman, A.F., Van Beek, L.P.H., Mogollón, J.M., Middelburg, J.J., 2016. Global riverine N and P transport to ocean increased during the 20th century despite increased retention along the aquatic continuum. *Biogeosciences* 13, 2441–2451.
- Beusen, A.H.W., Doelman, J.C., Van Beek, L.P.H., Van Puijenbroek, P.J.T.M., Mogollón, J.M., Van Grinsven, H.J.M., Stehfest, E., Van Vuuren, D.P., Bouwman, A.F., 2022. Exploring river nitrogen and phosphorus loading and export to global coastal waters in the Shared Socio-economic pathways. *Global environmental change* 72, 1.
- Beusen, A.H.W., Van Beek, L.P.H., Bouwman, L., Mogollón, J.M., Middelburg, J.B.M., 2015. Coupling global models for hydrology and nutrient loading to simulate nitrogen and phosphorus retention in surface water—description of IMAGE-GNM and analysis of performance. *Geosci Model Dev* 8, 4045–4067.
- Boettiger, C., Lang, D.T., Wainwright, P.C., 2012. rfishbase: exploring, manipulating and visualizing FishBase data from R. *J Fish Biol* 81, 2030–2039.
- Bouraoui, F., Grizzetti, B., Granlund, K., Rekolainen, S., Bidoglio, G., 2004. Impact of climate change on the water cycle and nutrient losses in a Finnish catchment. *Clim Change* 66, 109–126.
- Bouwman, A.F., Beusen, A.H.W., Billen, G., 2009. Human alteration of the global nitrogen and

- phosphorus soil balances for the period 1970-2050. *Global Biogeochem Cycles* 23.
- Brett, M.T., Benjamin, M.M., 2008. A review and reassessment of lake phosphorus retention and the nutrient loading concept. *Freshw Biol* 53, 194–211.
- Brown, M.B., Forsythe, A.B., 1974. Robust tests for the equality of variances. *J Am Stat Assoc* 69, 364–367.
- Bulle, C., Margni, M., Patouillard, L., Boulay, A.-M., Bourgault, G., De Bruille, V., Cao, V., Hauschild, M., Henderson, A., Humbert, S., 2019. IMPACT World+: a globally regionalized life cycle impact assessment method. *Int J Life Cycle Assess* 24, 1653–1674.
- Chapra, S.C., 1975. Comment on ‘An empirical method of estimating the retention of phosphorus in lakes’ by WB Kirchner and PJ Dillon. *Water Resour Res* 11, 1033–1034.
- Chen, J., He, D., Zhang, N., Cui, S., 2004. Characteristics of and human influences on nitrogen contamination in Yellow River system, China. *Environ Monit Assess* 93, 125–138.
- Chislock, M.F., Doster, E., Zitomer, R.A., Wilson, A.E., 2013. Eutrophication: causes, consequences, and controls in aquatic ecosystems. *Nature Education Knowledge* 4, 10.
- Chorus, I., Welker, M., 2021. Toxic cyanobacteria in water: a guide to their public health consequences, monitoring and management. Taylor & Francis.
- Clark, C.M., Bell, M.D., Boyd, J.W., Compton, J.E., Davidson, E.A., Davis, C., Fenn, M.E., Geiser, L., Jones, L., Blett, T.F., 2017. Nitrogen-induced terrestrial eutrophication: cascading effects and impacts on ecosystem services. *Ecosphere* 8, n/a.
- Comte, L., Olden, J.D., Tedesco, P.A., Ruhi, A., Giam, X., 2021. Climate and land-use changes interact to drive long-term reorganization of riverine fish communities globally. *Proceedings of the National Academy of Sciences - PNAS* 118, 1.
- Corvalan, C., Hales, S., McMichael, A.J., 2005. Ecosystems and human well-being: health synthesis. World Health Organization.
- Cosme, N., Hauschild, M.Z., 2017. Characterization of waterborne nitrogen emissions for marine eutrophication modelling in life cycle impact assessment at the damage level and global scale. *Int J Life Cycle Assess* 22, 1558–1570.
- Cosme, N., Jones, M.C., Cheung, W.W.L., Larsen, H.F., 2017. Spatial differentiation of marine eutrophication damage indicators based on species density. *Ecol Indic* 73, 676–685.
- Cosme, N., Mayorga, E., Hauschild, M.Z., 2018. Spatially explicit fate factors of waterborne nitrogen emissions at the global scale. *Int J Life Cycle Assess* 23, 1286–1296.
- D’angelo, D.J., Webster, J.R., Benfield, E.F., 1991. Mechanisms of stream phosphorus retention: an experimental study. *J North Am Benthol Soc* 10, 225–237.
- de Andrade, M.C., Ugaya, C.M.L., de Almeida Neto, J.A., Rodrigues, L.B., 2021. Regionalized phosphorus fate factors for freshwater eutrophication in Bahia, Brazil: an analysis of

- spatial and temporal variability. *Int J Life Cycle Assess* 1–20.
- De Klein, J.J.M., 2008. From Ditch to Delta, nutrient retention in running waters, PhD thesis.
- de Schryver, A.M., Brakkee, K.W., Goedkoop, M.J., Huijbregts, M.A.J., 2009. Characterization factors for global warming in life cycle assessment based on damages to humans and ecosystems.
- de Visser, S., Scherer, L., Huijbregts, M., Barbarossa, V., 2023. Characterization Factors for the Impact of Climate Change on Freshwater Fish Species. *Ecol Indic*.
- Derrick, B., Ruck, A., Toher, D., White, P., 2018. Tests for equality of variances between two samples which contain both paired observations and independent observations. *Journal of Applied Quantitative Methods* 13, 36–47.
- Díaz, S.M., Settele, J., Brondízio, E., Ngo, H., Guèze, M., Agard, J., Arneth, A., Balvanera, P., Brauman, K., Butchart, S., 2019. The global assessment report on biodiversity and ecosystem services: Summary for policy makers.
- Dodds, W.K., Smith, V.H., 2016. Nitrogen, phosphorus, and eutrophication in streams. *Inland Waters* 6, 155–164.
- Döll, P., Lehner, B., 2002. Validation of a new global 30-min drainage direction map. *J Hydrol (Amst)* 258, 214–231.
- Dorgham, M.M., 2014. Effects of eutrophication. *Eutrophication: Causes, Consequences and Control: Volume 2* 29–44.
- Downing, J.A., McCauley, E., 1992. The nitrogen: phosphorus relationship in lakes. *Limnol Oceanogr* 37, 936–945.
- Du, E., Terrer, C., Pellegrini, A.F.A., Ahlström, A., van Lissa, C.J., Zhao, X., Xia, N., Wu, X., Jackson, R.B., Methodology and statistics for the behavioural and social sciences, Leerstoel Heijden, 2020. Global patterns of terrestrial nitrogen and phosphorus limitation. *Nat Geosci* 13, 221–226.
- Duan, H., Loiselle, S.A., Zhu, L., Feng, L., Zhang, Y., Ma, R., 2015. Distribution and incidence of algal blooms in Lake Taihu. *Aquat Sci* 77, 9–16.
- Dudgeon, D., Arthington, A.H., Gessner, M.O., Kawabata, Z.-I., Knowler, D.J., Lévéque, C., Naiman, R.J., Prieur-Richard, A.-H., Soto, D., Stiassny, M.L.J., 2006. Freshwater biodiversity: importance, threats, status and conservation challenges. *Biological reviews* 81, 163–182.
- Ekau, W., Auel, H., Poertner, H.-O., Gilbert, D., 2010. Impacts of hypoxia on the structure and processes in pelagic communities (zooplankton, macro-invertebrates and fish). *Biogeosciences* 7, 1669–1699.
- El-Sadek, A., 2011. Spatial and temporal analysis of nitrogen transport and transformation in

- surface water. *Arab Gulf Journal of Scientific Research* 29, 51–58.
- FAOSTAT database collections, 2008. . Food and Agric. Org. of the U. N.
- Feng, K., Zhang, Z., Cai, W., Liu, W., Xu, M., Yin, H., Wang, A., He, Z., Deng, Y., 2017. Biodiversity and species competition regulate the resilience of microbial biofilm community. *Mol Ecol* 26, 6170–6182.
- Fillos, J., Swanson, W.R., 1975. The release rate of nutrients from river and lake sediments. *J Water Pollut Control Fed* 1032–1042.
- Fishnet2, 2019. Fishnet2 Database.
- Flörke, M., Eisner, S., 2011. The Development of Global Spatially Detailed Estimates of Sectoral Water Requirements, Past, Present and Future, Including Discussion of the Main Uncertainties, Risks and Vulnerabilities of Human Water Demand.
- Francoeur, S.N., Biggs, B.J.F., Smith, R.A., Lowe, R.L., 1999. Nutrient limitation of algal biomass accrual in streams: seasonal patterns and a comparison of methods. *J North Am Benthol Soc* 18, 242–260.
- Gade, A.L., Hauschild, M.Z., Laurent, A., 2021. Globally differentiated effect factors for characterising terrestrial acidification in life cycle impact assessment. *Sci Total Environ* 761, 143280–143280.
- Galloway, J., Dentener, F., Capone, D., Boyer, E., Howarth, R., Seitzinger, S., Asner, G., Cleveland, C., Green, P., Holland, E., Karl, D., Michaels, A., Porter, J., Townsend, A., Vorusmarty, C., 2004. Nitrogen Cycles: Past, Present, and Future. *Biogeochemistry* 70, 153–226.
- GBIF.org, 2019. GBIF occurrence.
- Geographical zone, 2009. New World Encyclopedia.
- Goolsby, D.A., Battaglin, W.A., Lawrence, G.B., Artz, R.S., Aulenbach, B.T., Hooper, R.P., Keeney, D.R., Stensland, G.J., 1999. Flux and sources of nutrients in the Mississippi-Atchafalaya River Basin: Topic 3 Report for the Integrated Assessment on Hypoxia in the Gulf of Mexico.
- Grizzetti, B., Passy, P., Billen, G., Bouraoui, F., Garnier, J., Lassaletta, L., 2015. The role of water nitrogen retention in integrated nutrient management: assessment in a large basin using different modelling approaches. *Environmental Research Letters* 10, 65008.
- Grooten, M., Almond, R.E.A., 2018. Living planet report-2018: aiming higher. WWF international.
- Grübler, A., Jefferson, M., McDonald, S., Messner, N., Nakichenovich, H. -H., Rogner, L., Schratzenholzer, 1995. Global Energy Perspectives to 2050 and Beyond. World Energy Counc./Int. Inst. for Appl. Syst. Anal.

- Haddeland, I., Skaugen, T., Lettenmaier, D.P., 2006. Anthropogenic impacts on continental surface water fluxes. *Geophys Res Lett* 33.
- Haines-Young, R., Potschin, M., 2010. The links between biodiversity, ecosystem services and human well-being. *Ecosystem Ecology: a new synthesis* 1, 110–139.
- Harrison, I., Abell, R., Darwall, W., Thieme, M.L., Tickner, D., Timboe, I., 2018. The freshwater biodiversity crisis. *Science (1979)* 362, 1369.
- Harrison, J.A., Beusen, A.H.W., Fink, G., Tang, T., Strokal, M., Bouwman, A.F., Metson, G.S., Vilmin, L., 2019. Modeling phosphorus in rivers at the global scale: recent successes, remaining challenges, and near-term opportunities. *Curr Opin Environ Sustain* 36, 68–77.
- Hart, M.R., Quin, B.F., Nguyen, M.L., 2004. Phosphorus runoff from agricultural land and direct fertilizer effects: A review. *J Environ Qual* 33, 1954–1972.
- Hartmann, J., Lauerwald, R., Moosdorf, N., 2019. GLORICH-Global river chemistry database. PANGAEA <https://doi.org/10.1594/PANGAEA/902360>.
- Hauschild, M., 2006. Spatial differentiation in life cycle impact assessment: a decade of method development to increase the environmental realism of LCIA. *Int J Life Cycle Assess* 11, 11–13.
- Hauschild, M., Potting, J., 2005. Spatial differentiation in Life Cycle impact assessment-The EDIP2003 methodology. *Environmental news* 80, 1–195.
- Havugimana, E., Bhople, B.S., Kumar, ANIL, Byiringiro, E., Mugabo, J.P., Kumar, ARUN, 2017. Soil pollution—major sources and types of soil pollutants. *Environmental science and engineering* 11, 53–86.
- Heike, H., Wickham, H., Kafadar, K., 2017. Letter-value plots: Boxplots for large data. *J. Comput. Graph. Stat* 26, 469–477.
- Hejzlar, J., Anthony, S., Arheimer, B., Behrendt, H., Bouraoui, F., Grizzetti, B., Groenendijk, P., Jeuken, M., Johnsson, H., Porto, A. Lo, 2009. Nitrogen and phosphorus retention in surface waters: an inter-comparison of predictions by catchment models of different complexity. *Journal of Environmental Monitoring* 11, 584–593.
- Hellweg, S., Milà i Canals, L., 2014. Emerging approaches, challenges and opportunities in life cycle assessment. *Science (1979)* 344, 1109 LP – 1113.
- Helmes, R.J.K., Huijbregts, M.A.J., Henderson, A.D., Jolliet, O., 2012. Spatially explicit fate factors of phosphorous emissions to freshwater at the global scale. *Int J Life Cycle Assess* 17, 646–654.
- Herschy, R.W., 2012. World Lake Database: International Lake Environment Committee Foundation (ILEC). *Encyclopedia of lakes and reservoirs*. Springer Netherlands, Dordrecht 920–921.

- Holdren, G.C., Armstrong, D.E., 1980. Factors affecting phosphorus release from intact lake sediment cores. *Environ Sci Technol* 14, 79–87.
- Howarth, R.W., Billen, G., Swaney, D., 1997. Regional nitrogen budgets and riverine N and P fluxes for the drainages to the North Atlantic Ocean: natural and human influences. *Oceanographic Literature Review* 5, 448.
- Huijbregts, M.A.J., Steinmann, Z.J.N., Elshout, P.M.F., Stam, G., Verones, F., Vieira, M., Zijp, M., Hollander, A., van Zelm, R., 2017. ReCiPe2016: a harmonised life cycle impact assessment method at midpoint and endpoint level. *Int J Life Cycle Assess* 22, 138–147.
- Hunkeler, D., 2014. LCA Compendium—The Complete World of Life Cycle Assessment (book series) Series editors: Walter Klöpffer and Mary Ann Curran. *Int J Life Cycle Assess* 19, 1779–1781.
- ICMBio, 2019. Portal da Biodiversidade - ICMBio.
- IPCC, (Intergovernmental Panel on Climate Change), 2018. Global warming of 1.5° C: an IPCC special report on the impacts of global warming of 1.5° C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change. Intergovernmental Panel on Climate Change.
- Janse, J.H., Kuiper, J.J., Weijters, M.J., Westerbeek, E.P., Jeuken, M.H.J.L., Bakkenes, M., Alkemade, R., Mooij, W.M., Verhoeven, J.T.A., 2015. GLOBIO-Aquatic, a global model of human impact on the biodiversity of inland aquatic ecosystems. *Environmental Science & Policy* 48, 99–114.
- Jenny, J., Francus, P., Normandeau, A., Lapointe, F., Perga, M., Ojala, A., Schimmelmann, A., Zolitschka, B., 2016. Global spread of hypoxia in freshwater ecosystems during the last three centuries is caused by rising local human pressure. *Glob Chang Biol* 22, 1481–1489.
- Jensen, H.S., Andersen, F.O., 1992. Importance of temperature, nitrate, and pH for phosphate release from aerobic sediments of four shallow, eutrophic lakes. *Limnol Oceanogr* 37, 577–589.
- Jeppesen, E., Kronvang, B., Meerhoff, M., Søndergaard, M., Hansen, K.M., Andersen, H.E., Lauridsen, T.L., Liboriussen, L., Beklioglu, M., Özen, A., 2009. Climate change effects on runoff, catchment phosphorus loading and lake ecological state, and potential adaptations. *J Environ Qual* 38, 1930–1941.
- Joly, C.A., 2023. The Kunming-Montréal Global Biodiversity Framework. *Biota Neotrop.*
- Jones, L., Provins, A., Holland, M., Mills, G., Hayes, F., Emmett, B., Hall, J., Sheppard, L., Smith, R., Sutton, M., Hicks, K., Ashmore, M., Haines-Young, R., Harper-Simmonds, L., 2014. A review and application of the evidence for nitrogen impacts on ecosystem services. *Ecosyst Serv* 7, 76–88.

- Jwaideh, M.A.A., Sutanudjaja, E.H., Dalin, C., 2022. Global impacts of nitrogen and phosphorus fertiliser use for major crops on aquatic biodiversity. *Int J Life Cycle Assess* 27, 1058–1080.
- Kalcic, M.M., Chaubey, I., Frankenberger, J., 2015. Defining Soil and Water Assessment Tool (SWAT) hydrologic response units (HRUs) by field boundaries. *International Journal of Agricultural and Biological Engineering* 8, 69–80.
- Kelly, C.A., Rudd, J.W.M., Hesslein, R.H., Schindler, D.W., Dillon, P.J., Driscoll, C.T., Gherini, S.A., Hecky, R.E., 1987. Prediction of biological acid neutralization in acid-sensitive lakes. *Biogeochemistry* 3, 129–140.
- Kim, L.-H., Choi, E., Stenstrom, M.K., 2003. Sediment characteristics, phosphorus types and phosphorus release rates between river and lake sediments. *Chemosphere* 50, 53–61.
- Kirchner, W.B., Dillon, P.J., 1975. An empirical method of estimating the retention of phosphorus in lakes. *Water Resour Res* 11, 182–183.
- Kroupova, K. H., Valentova, O., Svobodova, Z., A auer, P., Machova, J., 2018. Toxic effects of nitrite on freshwater organisms: a review. *Rev Aquac* 10, 525–542.
- Kramer, D.L., 1987. Dissolved oxygen and fish behavior. *Environ Biol Fishes* 18, 81–92.
- Kroeze, C., Bouwman, L., Seitzinger, S., 2012. Modeling global nutrient export from watersheds. *Curr Opin Environ Sustain* 4, 195–202.
- Kumar, A., 2005. *Biodiversity & Conservation*. APH Publishing.
- Larentis, C., Kotz Kliemann, B.C., Neves, M.P., Delariva, R.L., 2022. Effects of human disturbance on habitat and fish diversity in Neotropical streams. *PLoS One* 17, e0274191–e0274191.
- Lehner, B., Döll, P., 2004. Development and validation of a global database of lakes, reservoirs and wetlands. *J Hydrol (Amst)* 296, 1–22.
- Lehner, B., Liermann, C.R., Revenga, C., Vörösmarty, C., Fekete, B., Crouzet, P., Döll, P., Endejan, M., Frenken, K., Magome, J., 2011. High-resolution mapping of the world's reservoirs and dams for sustainable river-flow management. *Front Ecol Environ* 9, 494–502.
- Lehtiniemi, M., Engstrom-Ost, J., Viitasalo, M., 2005. Turbidity decreases anti-predator behaviour in pike larvae, *Esox lucius*. *Environ Biol Fishes* 73, 1–8.
- Lewis Jr, W.M., Wurtsbaugh, W.A., Paerl, H.W., 2011. Rationale for control of anthropogenic nitrogen and phosphorus to reduce eutrophication of inland waters. *Environ Sci Technol* 45, 10300–10305.
- Liu, S.M., Hong, G.-H., Zhang, J., Ye, X.W., Jiang, X.L., 2009. Nutrient budgets for large Chinese estuaries. *Biogeosciences* 6, 2245–2263.

- Liu, X., Beusen, A.H.W., Van Beek, L.P.H., Mogollón, J.M., Ran, X., Bouwman, A.F., 2018. Exploring spatiotemporal changes of the Yangtze River (Changjiang) nitrogen and phosphorus sources, retention and export to the East China Sea and Yellow Sea. *Water Res* 142, 246–255.
- Maavara, T., Parsons, C.T., Ridenour, C., Stojanovic, S., Dürr, H.H., Powley, H.R., van Cappellen, P., 2015. Global phosphorus retention by river damming. *Proceedings of the National Academy of Sciences* 112, 15603–15608.
- Maojian, L., Qianli, S., Hong, W., 2014. The filter effect of big reservoirs on dissolved silicate flux decrease in the Yangtze River drainage basin. *J Lake Sci* 26, 505–514.
- Marcé, R., Armengol, J., 2009. Modeling nutrient in-stream processes at the watershed scale using Nutrient Spiralling metrics. *Hydrol Earth Syst Sci* 13, 953.
- Mayorga, E., Seitzinger, S.P., Harrison, J.A., Dumont, E., Beusen, A.H.W., Bouwman, A.F., Fekete, B.M., Kroese, C., van Drecht, G., 2010. Global nutrient export from WaterSheds 2 (NEWS 2): model development and implementation. *Environmental Modelling & Software* 25, 837–853.
- McCrackin, M.L., Harrison, J.A., Compton, J.E., 2013. A comparison of NEWS and SPARROW models to understand sources of nitrogen delivered to US coastal areas. *Biogeochemistry* 114, 281–297.
- McDowell, R.W., Noble, A., Pletnyakov, P., Haggard, B.E., Mosley, L.M., 2020. Global mapping of freshwater nutrient enrichment and periphyton growth potential. *Sci Rep* 10, 3568–3568.
- McDowell, R.W., Sharpley, A.N., 2001. Approximating phosphorus release from soils to surface runoff and subsurface drainage. *J Environ Qual* 30, 508–520.
- Middleton, N., Thomas, D., 1997. World atlas of desertification.. ed. 2. Arnold, Hodder Headline, PLC.
- Miranda, R., Miqueleiz, I., Darwall, W., Sayer, C., Dulvy, N.K., Carpenter, K.E., Polidoro, B., Dewhurst-Richman, N., Pollock, C., Hilton-Taylor, C., Freeman, R., Collen, B., Böhm, M., 2022. Monitoring extinction risk and threats of the world's fishes based on the Sampled Red List Index. *Rev Fish Biol Fish* 32, 975–991.
- Mogollón, J.M., Beusen, A.H.W., van Grinsven, H.J.M., Westhoek, H., Bouwman, A.F., 2018a. Future agricultural phosphorus demand according to the shared socioeconomic pathways. *Global environmental change* 50, 149–163.
- Mogollón, J.M., Lassaletta, L., Beusen, A.H.W., Van Grinsven, H.J.M., Westhoek, H., Bouwman, A.F., 2018b. Assessing future reactive nitrogen inputs into global croplands based on the shared socioeconomic pathways. *Environmental Research Letters* 13, 44008.
- Morelli, B., Hawkins, T.R., Niblick, B., Henderson, A.D., Golden, H.E., Compton, J.E., Cooter,

- E.J., Bare, J.C., 2018. Critical review of eutrophication models for life cycle assessment. *Environ Sci Technol* 52, 9562–9578.
- Mori, A.S., Furukawa, T., Sasaki, T., 2013. Response diversity determines the resilience of ecosystems to environmental change. *Biological reviews* 88, 349–364.
- Mori, A.S., Lertzman, K.P., Gustafsson, L., 2017. Biodiversity and ecosystem services in forest ecosystems: a research agenda for applied forest ecology. *Journal of Applied Ecology* 54, 12–27.
- Mulholland, P.J., Helton, A.M., Poole, G.C., Hall, R.O., Hamilton, S.K., Peterson, B.J., Tank, J.L., Ashkenas, L.R., Cooper, L.W., Dahm, C.N., 2008. Stream denitrification across biomes and its response to anthropogenic nitrate loading. *Nature* 452, 202–205.
- Müller, B., Bryant, L.D., Matzinger, A., Wüest, A., 2012. Hypolimnetic oxygen depletion in eutrophic lakes. *Environ Sci Technol* 46, 9964–9971.
- Muralikrishna, I. v, Manickam, V., 2017. Life Cycle Assessment, Environmental Management.
- Nakhaei, N., Boegman, L., Mehdizadeh, M., Loewen, M., 2021. Three-dimensional biogeochemical modeling of eutrophication in Edmonton stormwater ponds. *Ecol Modell* 456, 109684.
- Nathan S Bryan, Hans van Grinsven, 2013. The Role of Nitrate in Human Health. *Advances in agronomy* 119, 153.
- Nedelciu, C.E., Ragnarsdottir, K.V., Schlyter, P., Stjernquist, I., 2020. Global phosphorus supply chain dynamics: Assessing regional impact to 2050. *Glob Food Sec* 26, 100426–100426.
- Norris, G.A., 2002. Impact characterization in the tool for the reduction and assessment of chemical and other environmental impacts: Methods for acidification, eutrophication, and ozone formation. *J Ind Ecol* 6, 79–101.
- Ogidi, O.I., Akpan, U.M., 2022. Aquatic biodiversity loss: Impacts of pollution and anthropogenic activities and strategies for conservation. In: *Biodiversity in Africa: Potentials, Threats and Conservation*. Springer, pp. 421–448.
- Payen, S., Civit, B., Golden, H., Niblick, B., Uwizeye, A., Winter, L., Henderson, A., 2019. Acidification and Eutrophication. In: Frischknecht, R., Jolliet, O. (Eds.), *Global Guidance for Life Cycle Impact Assessment Indicators: Volume 2*. Paris.
- Payen, S., Cosme, N., Elliott, A.H., 2021. Freshwater eutrophication: spatially explicit fate factors for nitrogen and phosphorus emissions at the global scale. *Int J Life Cycle Assess* 1–14.
- Payen, S., Ledgard, S.F., 2017. Aquatic eutrophication indicators in LCA: Methodological challenges illustrated using a case study in New Zealand. *J Clean Prod* 168, 1463–1472.
- Pfister, S., Bayer, P., 2014. Monthly water stress: spatially and temporally explicit consumptive

- water footprint of global crop production. *J Clean Prod* 73, 52–62.
- Pierrat, E., Barbarossa, V., Núñez, M., Scherer, L., Link, A., Damiani, M., Verones, F., Dorber, M., 2022. Global water consumption impacts on riverine fish species richness in Life Cycle Assessment. *Sci Total Environ* 854, 158702–158702.
- PLAN, A.B., 2008. The Atlas of Living Australia.
- Potting, J., Finnveden, G., 2015. LCA Compendium—The Complete World of Life Cycle Assessment (book series) Series editors: Walter Klöpffer and Mary Ann Curran. *Int J Life Cycle Assess* 20, 1338–1341.
- Potting, J., Hauschild, M.Z., 2006. Spatial differentiation in life cycle impact assessment - A decade of method development to increase the environmental realism of LCIA. *Int J Life Cycle Assess* 11, 11–13.
- Prakash, S., Verma, A.K., 2022. Anthropogenic activities and Biodiversity threats. *International Journal of Biological Innovations, IJBI* 4, 94–103.
- Reddy, K.R., Kadlec, R.H., Flaig, E., Gale, P.M., 1999. Phosphorus retention in streams and wetlands: a review. *Crit Rev Environ Sci Technol* 29, 83–146.
- Rosenbaum, R.K., Hauschild, M.Z., Boulay, A.-M., Fantke, P., Laurent, A., Núñez, M., Vieira, M., 2018. Life cycle impact assessment. *Life cycle assessment: theory and practice* 167–270.
- Rosenbaum, R.K., Hauschild, M.Z., Huijbregts (Eds.), M.A., 2015. *Life cycle impact assessment*. Springer.
- Rosenbaum, R.K., Margni, M., Jolliet, O., 2007. A flexible matrix algebra framework for the multimedia multipathway modeling of emission to impacts. *Environ Int* 33, 624–634.
- Roy, P.-O., Azevedo, L.B., Margni, M., van Zelm, R., Deschênes, L., Huijbregts, M.A.J., 2014. Characterization factors for terrestrial acidification at the global scale: A systematic analysis of spatial variability and uncertainty. *Sci Total Environ* 500–501, 270–276.
- Russo, R.C., Thurston, R. v, 1977. The Acute Toxicity of Nitrite to Fishes. *Recent Advances in Fish Toxicology*, Environmental Protection Agency, Ecological Research Series EPA 600/3-77-085, 118-131.
- Saunders, D.L., Kalff, J., 2001. Nitrogen retention in wetlands, lakes and rivers. *Hydrobiologia* 443, 205–212.
- Savage, J.M., 1995. Systematics and the biodiversity crisis. *Bioscience* 45, 673–679.
- Scherer, L., Gürdal, İ., van Bodegom, P.M., 2022. Characterization factors for ocean acidification impacts on marine biodiversity. *J Ind Ecol*.
- Scherer, L., Pfister, S., 2015. Modelling spatially explicit impacts from phosphorus emissions in agriculture. *Int J Life Cycle Assess* 20, 785–795.

- Schindler, David W. Vallentyne, J.R., 2008. Over fertilization of the World's Freshwaters and Estuaries. University of Alberta Press.
- Schindler, D.W., 2006. Recent advances in the understanding and management of eutrophication. *Limnol Oceanogr* 51, 356–363.
- Schipper, A.M., Barbarossa, V., 2022. Global congruence of riverine fish species richness and human presence. *Global ecology and biogeography* 31, 1501–1512.
- Schulte-Uebbing, L.F., Beusen, A.H.W., Bouwman, A.F., de Vries, W., 2022. From planetary to regional boundaries for agricultural nitrogen pollution. *Nature (London)* 610, 507–512.
- SDGs, 2015. Sustainable development goals. Available at this link: <https://www.un.org/sustainabledevelopment/inequality>.
- Seitzinger, S.P., Harrison, J.A., Dumont, E., Beusen, A.H.W., Bouwman, A.F., 2005. Sources and delivery of carbon, nitrogen, and phosphorus to the coastal zone: An overview of Global Nutrient Export from Watersheds (NEWS) models and their application. *Global Biogeochem Cycles* 19.
- Seitzinger, S.P., Styles, R. V., Boyer, E.W., Alexander, R.B., Billen, G., Howarth, R.W., Mayer, B., Van Breemen, N., 2002. Nitrogen retention in rivers: model development and application to watersheds in the northeastern USA. In: The Nitrogen Cycle at Regional to Global Scales. Springer, pp. 199–237.
- Seppala, J., Risbey, J., Meilinger, S., Norris, G., Lindfors, G.L., Goedkoop, M., 2001. Best available practice in life cycle assessment of climate change, stratospheric ozone depletion, photo-oxidant formation, acidification, and eutrophication-Backgrounds on general issues.
- Shinohara, R., Tsuchiya, K., Kohzu, A., 2021. Warming of water temperature in spring and nutrient release from sediment in a shallow eutrophic lake. *Journal of Water and Climate Change*.
- Sinada, F., Yousif, S., 2013. Water chemistry and quality of the Blue Nile at Khartoum.
- Smil, 2002. Nitrogen and food production: Proteins for human diets. *Ambio* 31, 126–131.
- Smil, V., 1997. Global population and the nitrogen cycle. *Sci Am* 277, 76–81.
- Smil, V., 1999. Nitrogen in crop production: an account of global flows. *Global Biogeochem Cycles* 13, 647–662.
- Smith, T.J., McKenna, C.M., 2013. A comparison of logistic regression pseudo R² indices. *Multiple Linear Regression Viewpoints* 39, 17–26.
- Smith, V.H., Joye, S.B., Howarth, R.W., 2006. Eutrophication of Freshwater and Marine Ecosystems. *Limnol Oceanogr* 51, 351–355.
- Spiess, A.-N., Neumeyer, N., 2010. An evaluation of R² as an inadequate measure for nonlinear models in pharmacological and biochemical research: a Monte Carlo approach. *BMC*

- Pharmacol 10, 6–6.
- splink, 2019. speciesLink.
- Statham, P.J., 2012. Nutrients in estuaries—an overview and the potential impacts of climate change. *Science of the total environment* 434, 213–227.
- Strokal, M., Kroeze, C., Wang, M., Bai, Z., Ma, L., 2016. The MARINA model (Model to Assess River Inputs of Nutrients to seAs): Model description and results for China. *Science of the Total Environment* 562, 869–888.
- Strömbäck, L., Pers, C., Strömqvist, J., Lindström, G., Gustavsson, J., 2019. A web based analysis and scenario tool for eutrophication of inland waters for Sweden and Europe. *Environmental Modelling & Software* 111, 259–267.
- Sun, C., Shen, Z., Liu, R., Xiong, M., Ma, F., Zhang, O., Li, Y., Chen, L., 2013. Historical trend of nitrogen and phosphorus loads from the upper Yangtze River basin and their responses to the Three Gorges Dam. *Environmental Science and Pollution Research* 20, 8871–8880.
- Sun, C.C., Shen, Z.Y., Xiong, M., Ma, F.B., Li, Y.Y., Chen, L., Liu, R.M., 2013. Trend of dissolved inorganic nitrogen at stations downstream from the Three-Gorges Dam of Yangtze River. *Environmental pollution* 180, 13–18.
- Sutanudjaja, E.H., Van Beek, R., Wanders, N., Wada, Y., Bosmans, J.H.C., Drost, N., Van Der Ent, R.J., De Graaf, I.E.M., Hoch, J.M., De Jong, K., 2018. PCR-GLOBWB 2: a 5 arcmin global hydrological and water resources model. *Geosci Model Dev* 11, 2429–2453.
- Swift, M.J., Izac, A.-M., Van Noordwijk, M., 2004. Biodiversity and ecosystem services in agricultural landscapes—are we asking the right questions? *Agric Ecosyst Environ* 104, 113–134.
- Tao, Y., Wei, M., Ongley, E., Li, Z., Jingsheng, C., 2010. Long-term variations and causal factors in nitrogen and phosphorus transport in the Yellow River, China. *Estuar Coast Shelf Sci* 86, 345–351.
- Tarkalson, D.D., Mikkelsen, R.L., 2004. Runoff phosphorus losses as related to soil test phosphorus and degree of phosphorus saturation on piedmont soils under conventional and no-tillage. *Commun Soil Sci Plant Anal* 35, 2987–3007.
- Tedesco, P.A., Beauchard, O., Bigorne, R., Blanchet, S., Buisson, L., Conti, L., Cornu, J.F., Dias, M.S., Grenouillet, G., Hugueny, B., 2017. Data Descriptor: A global database on freshwater fish species occurrence in drainage basins. *Sci. Data* 4, 1–6.
- Thurston, R. V., Russo, R.C., Vinogradov, G.A., 1981. Ammonia toxicity to fishes. Effect of pH on the toxicity of the unionized ammonia species. *Environ Sci Technol* 15, 837–840.
- Tilman, D., Fargione, J., Wolff, B., D'Antonio, C., Dobson, A., Howarth, R., Schindler, D., Schlesinger, W.H., Simberloff, D., Swackhamer, D., 2001. Forecasting agriculturally

- driven global environmental change. *Science* (1979) 292, 281–284.
- Trabucco, A., & Zomer, R.J., 2019. Global Aridity Index and Potential Evapotranspiration (ET0) Climate Database v2. figshare. Dataset.
- Turner, R.E., Rabalais, N.N., Justic, D., Dortch, Q., 2003. Global patterns of dissolved N, P and Si in large rivers. *Biogeochemistry* 64, 297–317.
- UNEP GEMS/Water Programme, 2007. Water Quality Outlook. Burlington, Canada.
- Van Beek, L.P.H., Wada, Y., Bierkens, M.F.P., 2011. Global monthly water stress: 1. Water balance and water availability. *Water Resour Res* 47.
- van Puijenbroek, P.J.T.M., Beusen, A.H.W., Bouwman, A.F., 2019. Global nitrogen and phosphorus in urban waste water based on the Shared Socio-economic pathways. *J Environ Manage* 231, 446–456.
- van Vliet, M.T.H., Flörke, M., Harrison, J.A., Hofstra, N., Keller, V., Ludwig, F., Spanier, J.E., Strokal, M., Wada, Y., Wen, Y., 2019. Model inter-comparison design for large-scale water quality models. *Curr Opin Environ Sustain* 36, 59–67.
- Venohr, M., Donohue, I., Fogelberg, S., Arheimer, B., Irvine, K., Behrendt, H., 2005. Nitrogen retention in a river system and the effects of river morphology and lakes. *Water Science and Technology* 51, 19–29.
- Verma, A.K., 2016. Biodiversity: Its different levels and values. *International Journal on Environmental Sciences* 7, 143–145.
- Verones, F., Hellweg, S., Antón, A., Azevedo, L.B., Chaudhary, A., Cosme, N., Cucurachi, S., de Baan, L., Dong, Y., Fantke, P., 2020. LC-IMPACT: A regionalized life cycle damage assessment method. *J Ind Ecol*.
- Verones, F., Kuipers, K., Núñez, M., Rosa, F., Scherer, L., Marques, A., Michelsen, O., Barbarossa, V., Jaffe, B., Pfister, S., Dorber, M., 2022. Global extinction probabilities of terrestrial, freshwater, and marine species groups for use in Life Cycle Assessment. *Ecol Indic* 142, 109204.
- Verones, F., Liao, X., de Souza, D.M., Fantke, P., Henderson, A., Posthuma, L., Laurent, A., 2019. Cross-cutting Issues. In: Frischknecht, R., Jolliet, O. (Eds.), *Global Guidance for Life Cycle Impact Assessment Indicators: Volume 2*.
- Villéger, S., Brosse, S., Mouchet, M., Mouillot, D., Vanni, M.J., 2017. Functional ecology of fish: current approaches and future challenges. *Aquat Sci* 79, 783–801.
- Vilmin, L., Mogollón, J.M., Beusen, A.H.W., van Hoek, W.J., Liu, X., Middelburg, J.J., Bouwman, A.F., 2020. Modeling process-based biogeochemical dynamics in surface freshwaters of large watersheds with the IMAGE-DGNM framework. *J Adv Model Earth Syst* e2019MS001796.

- Vollenweider, R.A., 1968. Scientific Fundamentals of the Eu-trophication of lakes and flowing waters, with Particular Reference to Nitrogen and Phosphorus as factor in Eutrophication. Paris Rep. Organization for Economic Cooperation and Development (DAS/CSI/68.27) 192.
- Vonlanthen, P., Bittner, D., Hudson, A.G., Young, K.A., Müller, R., Lundsgaard-Hansen, B., Roy, D., di Piazza, S., Largiader, C.R., Seehausen, O., 2012. Eutrophication causes speciation reversal in whitefish adaptive radiations. *Nature* 482, 357–362.
- Wada, Y., Bierkens, M.F.P., 2014. Sustainability of global water use: past reconstruction and future projections. *Environmental Research Letters* 9, 104003.
- Wang, H., García Molinos, J., Heino, J., Zhang, H., Zhang, P., Xu, J., 2021. Eutrophication causes invertebrate biodiversity loss and decreases cross-taxon congruence across anthropogenically-disturbed lakes. *Environ Int* 153, 106494–106494.
- Wernet, G., Bauer, C., Steubing, B., Reinhard, J., Moreno-Ruiz, E., Weidema, B., 2016. The ecoinvent database version 3 (part I): overview and methodology. *Int J Life Cycle Assess* 21, 1218–1230.
- Westin, D.T., 1974. Nitrate and Nitrite Toxicity to Salmonoid Fishes. *The Progressive fish-culturist* 36, 86–89.
- Whitfield, A., Elliott, A., 2002. Fishes as indicators of environmental and ecological changes within estuaries: a review of progress and some suggestions for the future. *J Fish Biol* 61, 229–250.
- Wilson, E.O., 1999. Biodiversity. National Academies Press, Washington.
- Withers, P.J.A., Jarvie, H.P., 2008. Delivery and cycling of phosphorus in rivers: a review. *Science of the total environment* 400, 379–395.
- Wohl, E., Barros, A., Brunsell, N., Chappell, N.A., Coe, M., Giambelluca, T., Goldsmith, S., Harmon, R., Hendrickx, J.M.H., Juvik, J., 2012. The hydrology of the humid tropics. *Nat Clim Chang* 2, 655–662.
- Wollheim, W.M., Vörösmarty, C.J., Bouwman, A.F., Green, P., Harrison, J., Linder, E., Peterson, B.J., Seitzinger, S.P., Syvitski, J.P.M., 2008. Global N removal by freshwater aquatic systems using a spatially distributed, within-basin approach. *Global Biogeochem Cycles* 22.
- Wollheim, W.M., Vörösmarty, C.J., Peterson, B.J., Seitzinger, S.P., Hopkinson, C.S., 2006. Relationship between river size and nutrient removal. *Geophys Res Lett* 33.
- Wood, E.F., Roundy, J.K., Troy, T.J., Van Beek, L.P.H., Bierkens, M.F.P., Blyth, E., de Roo, A., Döll, P., Ek, M., Famiglietti, J., 2011. Hyperresolution global land surface modeling: Meeting a grand challenge for monitoring Earth's terrestrial water. *Water Resour Res* 47.

- Wurtsbaugh, W.A., Paerl, H.W., Dodds, W.K., 2019. Nutrients, eutrophication and harmful algal blooms along the freshwater to marine continuum. Wiley Interdisciplinary Reviews: Water 6, e1373.
- Yan, W., Zhang, S., Wang, J., 2001. Nitrogen biogeochemical cycling in the Changjiang drainage basin and its effect on Changjiang River dissolved inorganic nitrogen. ACTA GEOGRAPHICA SINICA-CHINESE EDITION- 56, 507–514.
- Yule, G.U., Kendall, M.G., 1968. An introduction to the theory of statistics, Charles Griffin & Co. Ltd, London 66.
- Zhang, X., Zou, T., Lassaleta, L., Mueller, N.D., Tubiello, F.N., Lisk, M.D., Lu, C., Conant, R.T., Dorich, C.D., Gerber, J., Tian, H., Bruulsema, T., Maaz, T.M., Nishina, K., Bodirsky, B.L., Popp, A., Bouwman, L., Beusen, A., Chang, J., Havlík, P., Leclère, D., Canadell, J.G., Jackson, R.B., Heffer, P., Wanner, N., Zhang, W., Davidson, E.A., 2021. Quantification of global and national nitrogen budgets for crop production. Nat Food 2, 529–540.
- Zhou, J., Mogollón, J.M., van Bodegom, P.M., Barbarossa, V., Beusen, A.H.W., Scherer, L., 2023. Effects of nitrogen emissions on fish species richness across the world's freshwater ecoregions. Environ Sci Technol 57, 8347–8354.
- Zhou, J., Scherer, L., van Bodegom, P.M., Beusen, A.H.W., Mogollón, J.M., 2022a. A Comparison Between Global Nutrient Retention Models for Freshwater Systems. Frontiers in water 4:894604.
- Zhou, J., Scherer, L., van Bodegom, P.M., Beusen, A., Mogollón, J.M., Geochemistry, Bio-, hyo-, 2022b. Regionalized nitrogen fate in freshwater systems on a global scale. J Ind Ecol 26, 907–922.