ACKNOWLEDGEMENTS NISMOD LECTURES

Block 1

Fig. 1.2.1: Purvis, B., Mao, Y. & Robinson, D. Three pillars of sustainability: in search of conceptual origins. Sustain Sci 14, 681–695 (2019). https://doi.org/10.1007/s11625-018-0627-5

Figure 1.2.2: United Nations

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Figures 1.2.4,1.3.1 and 1.3.3: UNOPS 2018: Thacker S, Adshead D, Morgan G, Crosskey S, Bajpai A, Ceppi P, Hall JW & O'Regan N. Infrastructure: Underpinning Sustainable Development. UNOPS, Copenhagen, Denmark

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Block 2

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Figure 2.3.3: IPCC

Figure 2.4.1: taken from: Vital, S. (2019). Infrastructure Development through the Lens of Mitigation and Sustainable Development: The St . Lucia Case Study. University of the West Indies.

Figure 2.4.2: Government of St. Lucia

Block 3

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Figure 3.2.1, 3.4.1 and 3.4.2: Fuldauer, L. I., Ives, M. C., Adshead, D., Thacker, S., & Hall, J. W.,Journal of Cleaner Production, Volume 223, 20 June 2019, https://creativecommons.org/licenses/by/4.0/

Figure 3.2.2: Sapphire Vital

Block 4

Figures 4.1.1, 4.1.2, 4.3.1 and 4.4.8: Orlando Roman

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Figure 4.1.4: , Riahia, K. et al; The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview; Global Environmental Change, Volume 42, January 2017, Pages 153-168; Elsevier, https://creativecommons.org/licenses/by/4.0/

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Block 6

Figure 6.1.1: Lena I.Fuldauer, Matthew C.Ives, Daniel Adshead, Scott Thacker, Jim W.Hall; Participatory planning of the future of waste management in small island developing states to deliver on the Sustainable Development Goals; https://creativecommons.org/licenses/by/4.0/

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Figure 7.1.2: M. Hadi Amini, Ahmed Imteaj, Panos M. Pardalos; Interdependent Networks: A Data Science Perspective; Patterns, Volume 1, Issue 1, 2020, 100003, ISSN 2666-3899, https://creativecommons.org/licenses/by/4.0/

Figure 7.1.3: Jim W. Hall, Hamish Harvey, Lucy J. Manning, Adaptation thresholds and pathways for tidal flood risk management in London, Climate Risk Management, Volume 24, 2019, Pages 42-58, ISSN 2212-0963, https://creativecommons.org/licenses/by/4.0/

Figure 7.1.4: Michela Le Pira, Giuseppe Inturri, Matteo Ignaccolo, Alessandro Pluchino, Analysis of AHP Methods and the Pairwise Majority Rule (PMR) for Collective Preference Rankings of Sustainable Mobility Solutions, Transportation Research Procedia, Volume 10, 2015, Pages 777-787, ISSN 2352-1465, ttps://doi.org/10.1016/j.trpro.2015.09.031, https://creativecommons.org/licenses/by/4.0

Figure 7.2.1: Joost Buurman & Vladan Babovic (2016) Adaptation Pathways and Real Options Analysis: An approach to deep uncertainty in climate change adaptation policies, Policy and Society, 35:2, 137-150, DOI: 10.1016/j.polsoc.2016.05.002, https://creativecommons.org/licenses/by/4.0/

Figure 7.2.2: Mehmet Ümit Taner, Patrick Ray, Casey Brown, Robustness-based evaluation of hydropower infrastructure design under climate change, Climate Risk Management, Volume 18, 2017, Pages 34-50,https://doi.org/10.1016/j.crm.2017.08.002, https://creativecommons.org/licenses/by/4.0/

Figure 7.2.3: Fletcher, S., Strzepek, K., Alsaati, A., & Weck, O. (2019). Learning and flexibility for water supply infrastructure planning under groundwater resource uncertainty. Environmental Research Letters, 14, 114022, https://creativecommons.org/licenses/by/4.0/

Figure 7.3.1: McGowan L., Jay S., Kidd S. (2019) Scenario-Building for Marine Spatial Planning. In: Zaucha J., Gee K. (eds) Maritime Spatial Planning. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-319-98696-8_14, https://creativecommons.org/licenses/by/4.0/

Figure 7.3.2: Lempert R.J. (2019) Robust Decision Making (RDM). In: Marchau V., Walker W., Bloemen P., Popper S. (eds) Decision Making under Deep Uncertainty. Springer, Cham. https://doi.org/10.1007/978-3-030-05252-2_2, https://creativecommons.org/licenses/by/4.0/

Figure 7.3.3: Fletcher, S., Strzepek, K., Alsaati, A., & Weck, O. (2019). Learning and flexibility for water supply infrastructure planning under groundwater resource uncertainty. Environmental Research Letters, 14, 114022, https://creativecommons.org/licenses/by/4.0/

Figures 7.3.4, 7.4.1, 7.4.2 and Figure 7.4.3:: Lena I. Fuldauer, Matthew C. Ives, Daniel Adshead, Scott Thacker, Jim W. Hall, Participatory planning of the future of waste management in small island developing states to deliver on the Sustainable Development Goals, Journal of Cleaner Production, Volume 223, 2019, Pages 147-162, ISSN 0959-6526, https://doi.org/10.1016/j.jclepro.2019.02.269. https://creativecommons.org/licenses/by/4.0/

7.4.4: Adshead, D., Fuldauer, L., Thacker, S., Hickford, A., Rouhet, G., Muller, W.S., Hall, J.W., Nicholls, R. 2018. Evidence-Based Infrastructure: Curacao. National infrastructure systems modelling to support sustainable and resilient infrastructure development. United Nations Office for Project Services, Copenhagen, Denmark.

Figure 7.4.5: Matthew C Ives and Scott Thacker and Daniel Adshead and Jim W Hall and Adrian J Hickford and Robert J Nicholls and Trevor Sway Muwafaq and Abu Ayyash and Rob Jones and Nicholas O'regan. A Fast Track Analysis of infrastructure provision in Palestine 2018, ITRC

Figures 7.4.6 and 7.4.7: Adshead, D., Fuldauer, L.I., Thacker, S., Román García, O., Vital, S., Felix, F., Roberts, C., Wells, H., Edwin, G., Providence, A. and Hall, J.W. 2020. Saint Lucia: National Infrastructure Assessment. United Nations Office for Project Services, Copenhagen, Denmark.

Figure 8.1.1: Jim W. Hall, Jeroen C.J.H. Aerts, et. al.; Adaptation of Infrastructure Systems; https://creativecommons.org/licenses/by-nc-nd/4.0/

Figure 8.2.1: Scott Thacker, Raghav Pant, Jim W.Hall; System-of-systems formulation and disruption analysis for multi-scale critical national infrastructures, Reliability Engineering & System Safety, Volume 167, November 2017, Pages 30-41

Figures 8.2.2, 8.3.1, 8.3.2, 8.4.1, 8.4.2, 8.4.3 and 8.4.4: Raghav Pant

Figure 8.2.3: R. Pant, S. Thacker, J.W. Hall, D. Alderson, S. Barr, Critical infrastructure impact assessment due to flood exposure, 2018

Figure 8.2.4: Raghav Pant, Kash Barker, Jose Emmanuel Ramirez-Marquez, Claudio M. Rocco, Stochastic measures of resilience and their application to container terminals, Computers & Industrial Engineering, Volume 70, 2014, Pages 183-194.

Block 9

Figure 9.1.1: adapted by Raghav Pant from: Strategic analysis of the future of national infrastructure, Proceedings of the Institution of Civil Engineers: Civil Engineering

Figure 9.1.3: Tom Russell

Figures 9.2.1, 9.2.2, 9.2.3 and 9.2.5: Raghav Pant

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Figure 9.3.2: Barnaby Dobson, Gemma Coxon, Jim Freer, Helen Gavin, Mohammad Mortazavi-Naeini, Jim W. Hall; The Spatial Dynamics of Droughts and Water Scarcity in England and Wales;

Figure 9.3.3: Borgomeo, Edoardo and Hall, Jim W. and Fung, Fai and Watts, Glenn and Colquhoun, Keith and Lambert, Chris; Risk-based water resources planning: incorporating probabilistic nonstationary climate uncertainties, 2014

Figure 9.4.1: Department for Energy & Climate Change (DECC), House of Commons; https://publications.parliament.uk/pa/cm200910/cmselect/cmenergy/194/19404.htmhttp://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/

Figure 9.4.2: T. Russell and C. Zorn and A. Majid and R. Pant; Snkit: A Spatial Networks Data Cleaning Toolkit, 2020

Figure 9.4.4: Elco Koks, Raghav Pant, Scott Thacker & Jim W. Hall; Understanding Business Disruption and Economic Losses Due to Electricity Failures and Flooding; Springer;

Block 10

Figures 10.2.1 and 10.2.2: Increasing Infrastructure Resilience Background Report, February 2019 © 2019 Miyamoto International, Inc

Figure 10.2.3 and 10.3.2: R. Lamb, C. Keef, J. Tawn, S. Laeger, I. Meadowcroft, S. Surendran, P. Dunningand C. Batstone: A new method to assess the risk of local and widespread flooding on rivers and coasts;

Figures 10.2.4, 10.2.5 and 10.4.1: J. W. Hall, R. J. Dawson, P. B. Sayers, C. Rosu, J. B. Chatterton and R. Deakin, A methodology for national-scale flood risk assessment.

Figure 10.3.1: Ross Towe, Jonathan Tawn, Rob Lamb; Why extreme floods are more common than you might think; 2018

Figure 10.4.2: Koks, E., Pant, R., Thacker, S. *et al.* Understanding Business Disruption and Economic Losses Due to Electricity Failures and Flooding. *Int J Disaster Risk Sci* **10,** 421–438 (2019).

Figure 10.4.3: Rob Lamb, Paige Garside, Raghav Pant, Jim W. Hall; A Probabilistic Model of the Economic Risk to Britain's Railway Network from Bridge Scour During Floods; 2019

Block 11:

Figure 11.1.1: Elco Koks, Raghav Pant, Scott Thacker & Jim W. Hall; Understanding Business Disruption and Economic Losses Due to Electricity Failures and Flooding.

Figures 11.1.3,11.2.2 and 11.3.3: R. Pant, S. Thacker, J.W. Hall, D. Alderson and S. Barr, Critical infrastructure impact assessment due to flood exposure. © 2016 The Chartered Institution of Water and Environmental Management (CIWEM) and John Wiley & Sons Ltd

Figure 11.2.1: E. E. Koks, J. Rozenberg, C. Zorn, M. Tariverdi, M. Vousdoukas, S. A. Fraser, J. W. Hall & S. Hallegatte, A global multi-hazard risk analysis of road and railway infrastructure assets, 2019

Figure 11.2.3: Jim W. Hall, Jeroen C.J.H. Aerts, et. al. C. 2019. Adaptation of Infrastructure Systems: Background Paper for the Global Commission on Adaptation. Oxford: Environmental Change Institute, University of Oxford

Figures 11.2.4 and 11.3.1: Pant, R., Thacker, S., Hall, J. W., Alderson, D. and Barr, S., Journal of Flood Risk Management, Critical infrastructure impact assessment due to flood exposure, 2018

Figure 11.3.2: National Infrastructure Commission | Anticipate, React, Recover: Resilient infrastructure systems; May 2020

Figure 11.4.1: Koks, E., Pant, R., Thacker, S. *et al.* Understanding Business Disruption and Economic Losses Due to Electricity Failures and Flooding. *Int J Disaster Risk Sci* **10,** 421–438 (2019).

Block 12

Figure 12.1.1: Hannah Ritchie and Max Roser

Figure 12.1.2: Peter Lehmann, Jonas von Ruette, Dani Or; Deforestation Effects on Rainfall-Induced Shallow Landslides: Remote Sensing and Physically-Based Modelling, 2019; John Wiley & Sons

Figure 12.1.3: Extension of urban sprawl in selected cities, 1975-2015; Espace Mondial, l'Atlas

Figure 12.1.4: Di Baldassarre, G. et al. (2018) 'Water shortages worsened by reservoir effects', Nature Sustainability. Springer US, 1(11), pp. 617–622

Figure 12.2.1: European Environmental Agency

Figure 12.2.2: Geophysical Fluid Dynamics Laboratory

Figure 12.2.3, 12.2.4 and 12.2.5: van Vuuren, D.P., Edmonds, J., Kainuma, M. et al. The representative concentration pathways: an overview. Climatic Change 109, 5 (2011). https://doi.org/10.1007/s10584-011-0148-z

Figure 12.2.6: CarbonBrief (2019) CMIP6: the next generation of climate models explained, Climate Modelling. Available at: https://www.carbonbrief.org/cmip6-the-next-generation-of-climate-models-explained

Figure 12.2.7: Almazroui, M. et al. (2020) 'Projected Change in Temperature and Precipitation Over Africa from CMIP6', Earth Systems and Environment. Springer International Publishing, 4(3), pp. 455–475. doi: 10.1007/s41748-020-00161-x.

Figure 12.3.2: Hirabayashi, Y. et al. (2021) 'Global exposure to flooding from the new CMIP6 climate model projections', Scientific Reports. Nature Publishing Group UK, 11(1), pp. 1–7. doi: 10.1038/s41598-021-83279-w.

Figure 12.3.3: Forzieri, G. et al. (2018) 'Escalating impacts of climate extremes on critical infrastructures in Europe', Global Environmental Change. Elsevier Ltd, 48(April 2017), pp. 97–107. doi: 10.1016/j.gloenvcha.2017.11.007.

Figure 12.3.4: Wong & Keller (2017) Deep Uncertainty Surrounding Coastal Flood Risk Projections: A Case Study for New Orleans

Figures 12.4.1, 12.4.2, 12.4.3, 12.4.4, 12.4.5 and 12.4.6: Pant, R. et al. (2019) Argentina – Transport risk analysis. Oxford, United Kingdom.

Block 13

Figure 13.1.1: Thacker, S. et al. (2019) 'Infrastructure for sustainable development', Nature Sustainability. Springer US, 2(4), pp. 324–331. doi: 10.1038/s41893-019-0256-8.

Figure 13.1.3: Bauer et al 2017; Shared Socio-Economic Pathways of the Energy Sector – Quantifying the Narratives, Global Environmental Change, Volume 42, 2017, Pages 316-330, ISSN 0959-3780, https://doi.org/10.1016/j.gloenvcha.2016.07.006.

Figures 13.1.4 and 13.1.5: Gao, J. and O'Neill, B. C. (2020) 'Mapping global urban land for the 21st century with data-driven simulations and Shared Socioeconomic Pathways', Nature Communications. Springer US, 11(1), pp. 1–12. doi: 10.1038/s41467-020-15788-7.

Figure 13.2.1: Zarfl, C. et al. (2015) 'A global boom in hydropower dam construction', Aquatic Sciences, 77(1), pp. 161–170. doi: 10.1007/s00027-014-0377-0.

Figure 13.2.2: Hanson, S. E. and Nicholls, R. J. (2020) 'Demand for Ports to 2050: Climate Policy, Growing Trade and the Impacts of Sea-Level Rise', Earth's Future, 8(8). doi: 10.1029/2020EF001543.

Figure 13.2.3: Jasper Verschuur

Figure 13.2.4: Pant, R. et al. (2018) Transport Risk Analysis for The United Republic of Tanzania.

Figure 13.3.1: McKinseyMcKinsey & Company (2020) How COVID-19 has pushed companies over the technology tipping point—and transformed business forever. Available at: https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/how-covid-19-has-pushed-companies-over-the-technology-tipping-point-and-transformed-business-forever.

Figure 13.3.2: Di Baldassarre, G. et al. (2015) 'Debates-Perspectives on socio-hydrology: Capturing feedbacks between physical and social processes', Water Resources Research, 51(6), pp. 4770–4781. doi: 10.1002/2014WR016416.; AGU

Figure 13.3.3: Oughton, E. (2021) Policy options for digital infrastructure strategies : A simulation model for broadband universal service in Africa. Available at: https://arxiv.org/abs/2102.03561.

Figure 13.3.4: Brookings (2019) Charts of the Week: China's Belt and Road Initiative, Brookings now. Available at: https://www.brookings.edu/blog/brookings-now/2019/05/17/charts-of-the-week-chinas-belt-and-road-initiative.

Figures 13.4.5, 13.4.6, 13.4.7 and 13.4.8: Adshead, D. et al. Saint Lucia: National Infrastructure Assessment. (United Nations Office for Project Services, 2020).

Block 14

Figure 14.1.1: Jongman, B. (2018) 'Effective adaptation to rising flood risk', Nature Communications, 9(1), pp. 9–11. doi: 10.1038/s41467-018-04396-1.

Figure 14.1.2: APFM (2020) Integrated Flood Risk Management Cascade, Measures and Designing Strategies for Integrated Flood Management. Available at: https://www.floodmanagement.info/integrated-flood-risk-management-cascade.

Figure 14.1.4: Hochrainer-Stigler, S. et al. (2020) 'Enhancing resilience of systems to individual and systemic risk: Steps toward an integrative framework', International Journal of Disaster Risk Reduction, 51(January). doi: 10.1016/j.ijdrr.2020.101868.

Figure 14.1.5: Pant, R. et al. (2020) Resilience Study Research for NIC: Systems analysis of interdependent network vulnerabilities. Oxford.

Figure 14.2.1: Kate Raworth, Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist.

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Figure 14.3.1: Editors: Marchau, V.A.W.J., Walker, W.E., Bloemen, P.J.T.M., Popper, S.W; Decision Making under Deep Uncertainty From Theory to Practice; 2019 Springer

Figure 14.3.2: Edoardo Borgomeo, Mohammad Mortazavi-Naeini, Jim W. Hall, Benoit P. Guillod; Earth's Future' Risk, Robustness and Water Resources Planning Under Uncertainty, 2018, AGU

Figure 14.3.3: Aman Majid

Figure 14.4.3: Poff, N., Brown, C., Grantham, T. *et al.* Sustainable water management under future uncertainty with eco-engineering decision scaling. *Nature Clim Change* **6,** 25–34 (2016). https://doi.org/10.1038/nclimate2765

Figure 14.4.4: Haasnoot, M. et al. (2013) 'Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world', Global Environmental Change, 23(2), pp. 485–498. doi: 10.1016/j.gloenvcha.2012.12.006. Elsevier

Figures 14.4.5 and 14.4.6: Hall, J. W., Harvey, H. and Manning, L. J. (2019) 'Adaptation thresholds and pathways for tidal flood risk management in London', Climate Risk Management. Elsevier, 24(August 2018), pp. 42–58. doi: 10.1016/j.crm.2019.04.001.Figure 11.1.1: © 2016 The Chartered Institution of Water and Environmental Management (CIWEM) and John Wiley & Sons Ltd

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Figures 15.2.1 and 15.2.3: WWF. 2018. Grooten, M. and Almond, R.E.A.(Eds) Living Planet Report 2018. Aiming Higher. WWF, Gland, Switzerland.

Figure 15.2.2: WWF. 2020. Marion A. Osieyo, Nature in all Goals, WWF, UK.

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Figures 15.2.5 and 15.2.6: United Nations

Figure 15.2.7: Targeting adaptation to safeguard sustainable development against climate-change impacts; Lena Fuldauer, Scott Thacker, Robyn Haggis, Francesco Fuso Nerini, Robert Nicholls, Jim Hall; https://creativecommons.org/licenses/by/4.0/

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Figure 15.4.6: UNOPS, UNEP and Oxford University Environmental Change Institute. 2019. The SustainABLE tool.

Block 16

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Figure 16.2.2: Krause-Jensen, Dorte , Carlos Duarte, and Helene Frigstad. 2018. "Marine forests - Nature's own carbon capture and storage." In.: Science Nordic.

Figure 16.2.3: Duarte, C. M., Losada, I. J., Hendriks, I. E., Mazarrasa, I. & Marbà, N. The role of coastal plant communities for climate change mitigation and adaptation. Nature Climate Change 3, 961-968, doi:10.1038/nclimate1970 (2013).

Figure 16.2.4: Quader, Mohammad Abdul, Shefali Agrawal, and Matthieu Kervyn. 2017. 'Multi-decadal land cover evolution in the Sundarban, the largest mangrove forest in the world', Ocean & Coastal Management, 139: 113-24.

Figure 16.2.5: Carro, I., Seijo, L., Nagy, G. J., Lagos, X. & Gutiérrez, O. Building capacity on ecosystem-based adaptation strategy to cope with extreme events and sea-level rise on the Uruguayan coast.

International Journal of Climate Change Strategies and Management 10, 504-522, doi:10.1108/IJCCSM-07-2017-0149 (2018); https://creativecommons.org/licenses/by/4.0/

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Figure 17.1.3: IUCN. 2016. The Economics of the Atewa Forest Range, Ghana.

Figures 17.1.4 and 17.3.2: Left: Browder, Greg; Ozment, Suzanne; Rehberger Bescos, Irene; Gartner, Todd; Lange, Glenn-Marie. 2019. Integrating Green and Gray : Creating Next Generation Infrastructure. Washington, DC: World Bank and World Resources Institute. © World Bank and World Resources Institute. https://openknowledge.worldbank.org/handle/10986/31430 License: CC BY 4.0; Right: UNEP. 2014. Green Infrastructure Guide for Water Management.

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Figure 17.3.1: Hijdra, A., 2021. Ports and nature-based solutions. An overview of 12+1 Financial Instruments.

Figure 17.3.2, 17.3.7, 17.4.4 and 17.4.7: Browder, Greg; Ozment, Suzanne; Rehberger Bescos, Irene; Gartner, Todd; Lange, Glenn-Marie. 2019. Integrating Green and Gray : Creating Next Generation Infrastructure. Washington, DC: World Bank and World Resources Institute. © World Bank and World Resources Institute. https://openknowledge.worldbank.org/handle/10986/31430 License: CC BY 4.0

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Climate Change and to Deliver Biodiversity. Nature-Based Solutions to Climate Change Adaptation in Urban Areas pp 159-183|

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Block 18

Figure 18.1.1: Monty, F., R. Murti, S. Miththapala, and C. (eds) Buyck. 2017. "Ecosystems protecting infrastructure and communities: lessons learned and guidelines for implementation." In. Gland, Switzerland.

Figure 18.2.1: IUCN (2020). Guidance for using the IUCN Global Standard for Nature-based Solutions. A user-friendly framework for the verification, design and scaling up of Nature-based Solutions. First edition. Gland, Switzerland: IUCN.

Figure 18.3.1: Sarkis, Samia, Pieter J. H. van Beukering, Emily McKenzie, Luke Brander, Sebastiaan Hess, Tadzio Bervoets, Lois Looijenstijn-van der Putten, and Mark Roelfsema. 2013. 'Total economic value of Bermuda's coral reefs: a summary.' in, Coral Reefs of the United Kingdom Overseas Territories (Springer Nature).

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