

## Designing a global mechanism for intergovernmental biodiversity financing

---

Nils Droste, Joshua Farley, Irene Ring, Peter H. May, Taylor Ricketts

**Summary:** The Convention on Biological Diversity (CBD) and the Nagoya Protocol display a broad international consensus for biodiversity conservation and an equitable sharing of benefits. The CBD Aichi biodiversity targets show a need for both additional action and enhanced mobilization of financial resources. A proposal of financial burden sharing among states has not yet been developed. We contribute a policy design study for a global scale financial mechanism to support biodiversity conservation through intergovernmental transfers. We develop three design options: ecocentric, socio-ecological and anthropocentric. We analyze the corresponding incentives to reach the Aichi target of terrestrial protected area coverage by 2020. The socio-ecological policy design provides the strongest incentives for states with the largest distance to the Aichi target. Thereby, we provide a new and innovative instrument proposal for global biodiversity financing. We anticipate it to be a starting point for more specific policy dialogues on intergovernmental burden and benefit sharing.

In order to safeguard human survival on the planet through conservation and sustainable use of biological diversity, the Convention on Biological Diversity (CBD) aims at institutionalizing benefit sharing and appropriate funding mechanisms. While the convention recognizes national sovereignty as a governing principles, it also affirms that the conservation of biodiversity is a “common concern of humankind”.<sup>1</sup> The parties to the convention agreed upon implementing biodiversity strategies, monitoring, and conservation policies nationally. On the international arena, access and benefit sharing (ABS) mechanisms have further been specified in the Nagoya Protocol. These mechanisms are meant to facilitate ‘fair and equitable sharing of benefits’ that originate from the utilization of genetic resources and ‘appropriate funding’.<sup>2</sup> In this context benefits are understood in terms of both economic and non-economic values which can be shared between states and between private and state actors.<sup>3-4</sup> Private benefits may refer to direct use values from bioprospecting and marketization of inputs gained from genetic resource material and information.<sup>2,5-7</sup> Public benefits range from insurance values of safeguarding habitats, ecosystems and life sustaining biospheric systems, over

option values of yet unknown future uses, to spill-over benefits that arise from spatial interactions among ecosystems such as the multiple habitats of migratory species.<sup>8</sup>

There are 20 strategic targets of the CBD for 2020, the Aichi targets. They are structured in 5 goals, i) mainstreaming biodiversity policies, ii) pressure reduction and sustainable use, iii) safeguarding ecosystems, species and genetic diversity, iv) benefit enhancement, and v) improving implementation.<sup>9</sup> Most target elements show some but insufficient progress to reach the Aichi targets by 2020, some do not show no significant overall progress, some show movement away from the target, and very few target elements show sufficient progress.<sup>10</sup> One of the main causes of insufficient progress is inadequate financing.<sup>11-15</sup> Most conservation spending in developed countries comes from domestic sources while developing countries mainly rely on inter- and transnational biodiversity financing.<sup>11</sup> The international funding comes through the UN Agencies like the Global Environmental Facility (GEF) who finances CBD related projects and further bilateral agreements.<sup>11</sup> The lack of overall progress towards the Aichi targets calls for additional action and innovative financial mechanisms.<sup>10</sup> Article 10 of the Nagoya Protocol declares that a global multilateral access and benefit-sharing mechanism (ABS) 'to support the conservation of biological diversity' shall be considered by the parties.<sup>2</sup> The ABS mechanisms are expected to create economic incentives for biodiversity conservation but no direct (financial) obligations arise from the formulation of the article and an corresponding mechanism design has yet to be developed.<sup>3-4</sup> We approach the search for an ABS innovation guided by a principle of fiscal equivalence.<sup>16</sup> The principle has been developed for the financing of public goods and services. It states that those who benefits from the good in question should also pay for the costs of provision. It is meant to ensure an efficient provision of public goods and services. While private beneficiaries would thus also have to contribute to a corresponding ABS mechanism or fund<sup>7</sup>, we will focus on intergovernmental co-financing. Conservation does not just provide national benefits, it also yields transnational public benefits such as insurance values and spill-over benefits.<sup>8</sup> In case of spill-over benefits, the principle of fiscal equivalence calls for intergovernmental transfers in order to compensate those who bear the costs of provision.<sup>16</sup> A

resulting global ecological fiscal transfer (EFT)<sup>17</sup> mechanism for the benefit sharing across nation states would provide an important and innovative contribution to reaching Aichi targets. This is especially the case since such a mechanism may incentivize nations to supply global benefits of conserving biodiversity through protected areas.<sup>18-22</sup>

### ***Developing mechanism designs***

Largely unnoticed by the international community, Brazilian states have invented and implemented EFT since the early 1990s. In order to compensate municipalities for the opportunity costs of hosting state and national protected areas on their territory, the state of Paraná implemented a mechanism that distributes a portion of tax revenue according to the the location of protected areas in 1991.<sup>17-20</sup> Several other Brazilian have subsequently implemented their own EFT schemes such that currently 17 out of 26 Brazilian states have adopted various designs of the instrument.<sup>19-20,22</sup> First impact studies show that the implementation of EFT schemes creates an incentive for the receiving municipalities to increase municipal protected areas.<sup>22-23</sup> In recent years EFT have gained international recognition and Portugal has implemented a similar scheme at the national level in 2007.<sup>24</sup> Several proposals have been developed for Switzerland, Germany, Poland, France, Indonesia and India and the EU network of protected areas.<sup>25-32</sup> An adaptation to the global level has been proposed<sup>21</sup> but has not yet been designed or simulated.

Based on the Brazilian instrument, we propose three design options. The *ecocentric design* would be based on protected area extent per country, irrespective of any socio-economic factors. Each country's environmental indicator,  $EI$ , would be calculated as the sum of all protected areas  $PA$  weighted with  $w_k$  regarding the International Union for Conservation of Nature (IUCN) protected area category  $k$  according to their contribution to conservation goals (equation 1).

$$EI_i = \sum_{j=1}^n w_k PA_{ij} \quad (1)$$

The *socio-ecological design* would furthermore take into account the country size and fairness by accounting for relative protected area share per country's area – which is in line with the percentage goal of Aichi target 11 – plus a reversed Human Development Index (HDI), where less developed countries would obtain a relatively larger share of the fund (equation 2).

$$EI_i = \sum_{j=1}^n w_k \frac{PA_{ij}}{area_i} (1 - HDI_i) \quad (2)$$

The *anthropocentric design* would extent the socio-ecological design by accounting for population density, which would increase the effect for countries that have both many protected areas and people – which would maximize people's benefits from protected areas (equation 3).

$$EI_i = \sum_{j=1}^n w_k \frac{PA_{ij}}{area_i} (1 - HDI_i) \frac{pop_i}{area_i} \quad (3)$$

The fund would then be distributed among all countries according to their  $EI$  (equation 4).

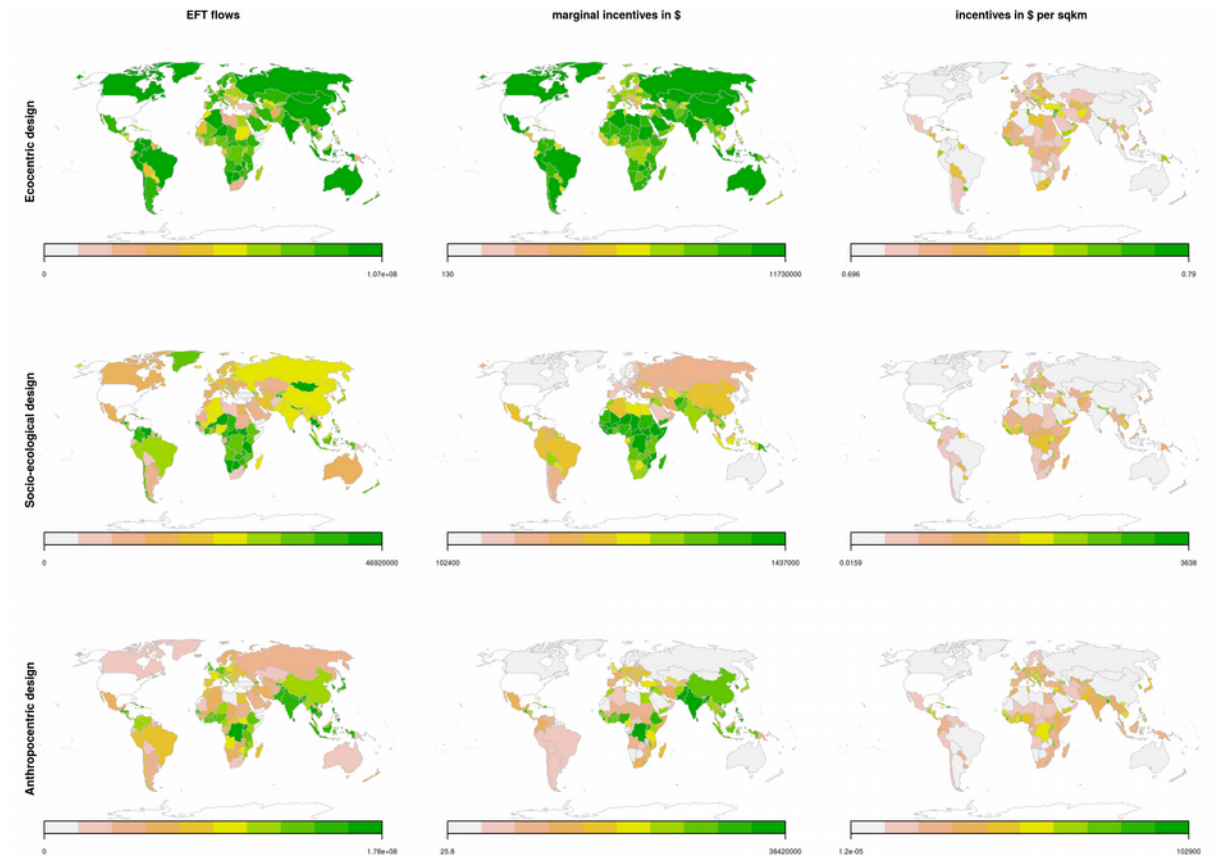
$$EFT_i = \frac{fund \times EI_i}{\sum_{k=1}^m EI_k} \quad (4)$$

For details on the calculations beyond the general design options see the method section.

### **Resulting financial flows & incentives**

For the mechanisms we have computed the protected area extent and relative shares based on United Nations Environment Programme (UNEP) Protected Planet data for all IUCN categorized protected areas and Global Administrative Areas country shapefiles.<sup>33-34</sup> For the spatial analysis we followed the UNEP guide, for details see the method section link. The fairness indicator is based on United Nations Development Programme (UNDP) HDI data.<sup>35</sup> Population data has been provided by the World Bank.<sup>36</sup> We have simulated the resulting EFT per country for each of the design options for all national CBD parties (first column, Figure 1) – which includes all UN Member states except the USA. Then we computed the resulting incentives as a change in EFT flows to a country if it unilaterally

increases its protected areas by 1 per cent of its area, *ceteris paribus* (second column, Figure 1). We also calculated how much of an incentive would result per square kilometer (third column, Figure 1).

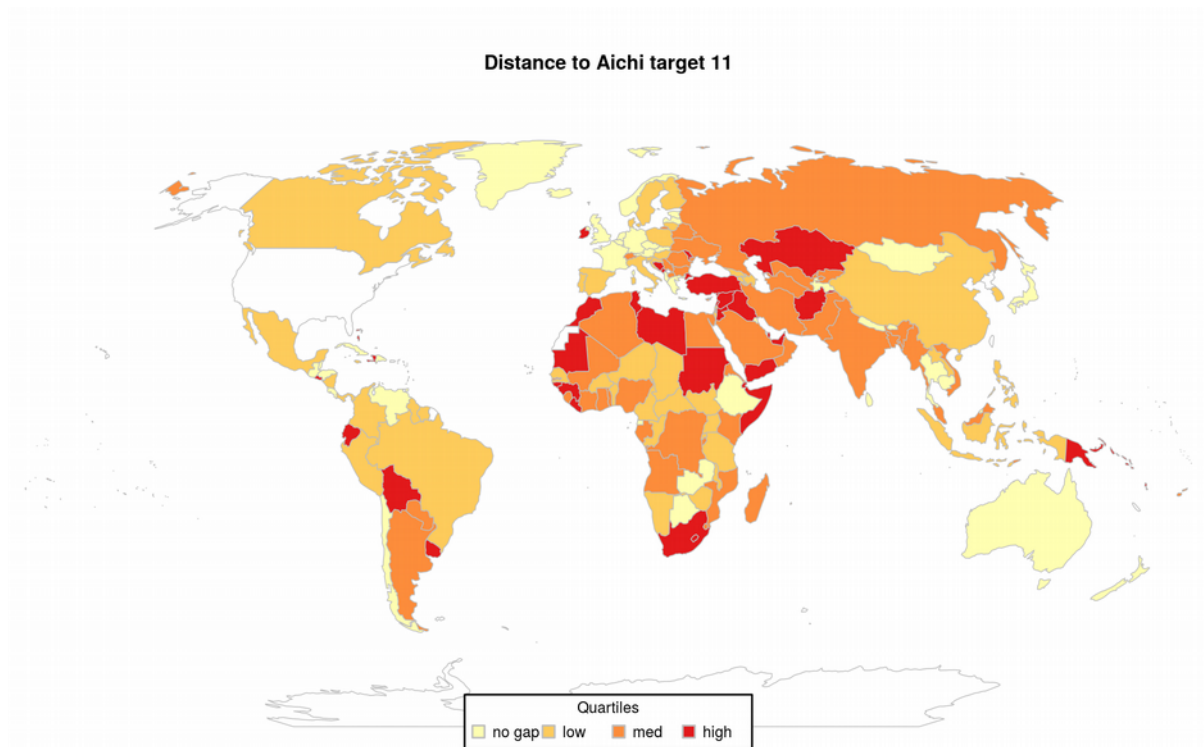


**Figure 1:** Global maps of different EFT designs and the resulting incentives. Incentives are computed as the marginal and per sqkm change in EFT flows for a unilateral protected area increase of 1 per cent total area per country, *ceteris paribus*. The countries are color coded in deciles and the legends display an equal spacing per quantiles while the actual values are distributed differently among deciles. Maps have a Robinson projection. Source: authors' elaboration.

### Design choice based on Aichi target 11

In order to assess which instrument design is the best choice we evaluate how far countries are from reaching Aichi target 11 which states that by 2020 17 per cent of all terrestrial land shall be protected (Figure 2).

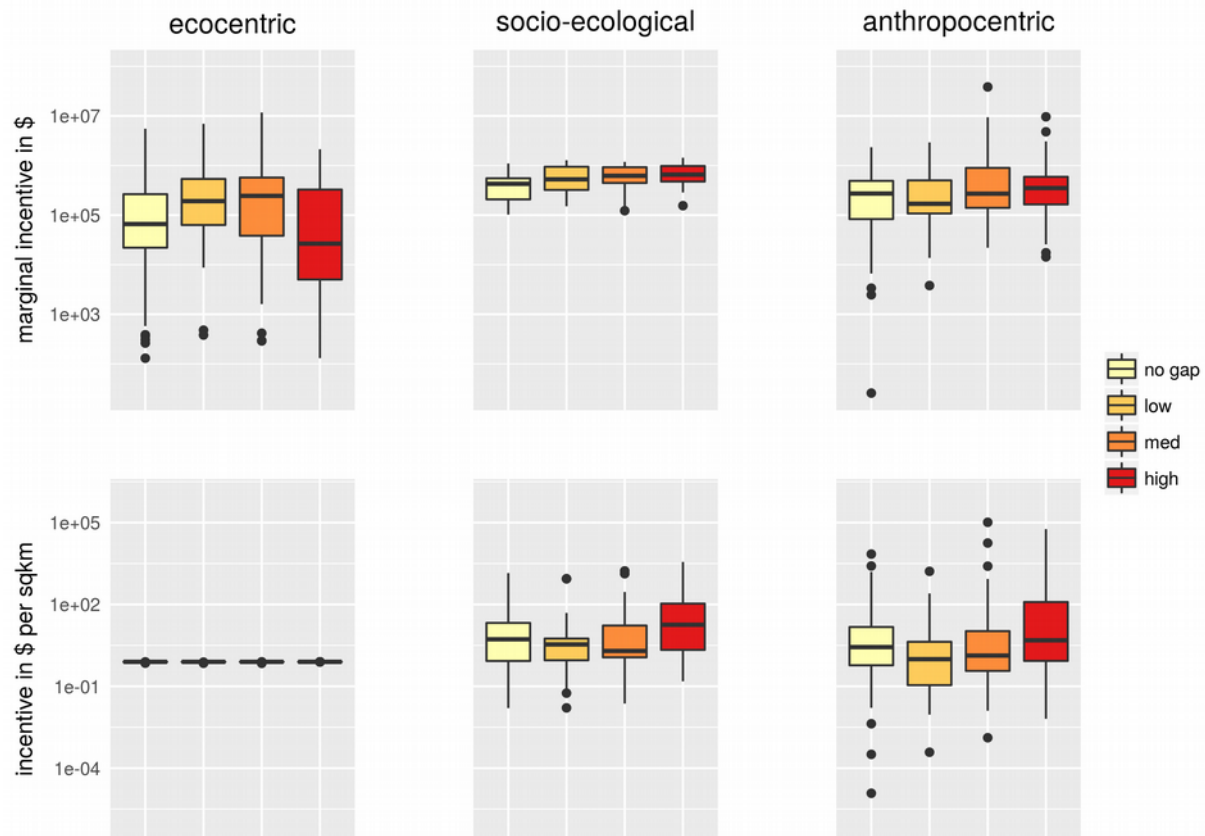
**Figure 2:** Global map of countries' distances to fulfill Aichi target 11 of 17 % terrestrial protected areas by 2020, calculated as 17 minus countries current protected area share in percent. Only IUCN categorized protected areas are considered. The



countries are grouped in quartiles. Quartile colors are lightyellow for a distance of less than 0 up to 1.14, lightorange for up to 8.91, darkorange for up to 15.10 , red for up to 17.00. Non-CBD countries are white. The map has a Robinson projection. Source: authors` elaboration.

We grouped the countries' distances to Aichi target 11 by quartiles and computed the distribution of both marginal and per square kilometer incentives per quartiles for each of the three design options. The design choice is based on the following consideration. The strongest incentive should go to those countries that are the farthest from reaching the Aichi target. They are the ones that need to increase protected area share the most and thus should be incentivized most. Figure 3 provides boxplots of incentives per design for both marginal and per square kilometer incentives. The socio-ecological design consistently provides the highest mean incentive for the quartile of countries that have the largest distance to reaching Aichi target 11 and thus ranks first. The social design ranks second and the ecological design comes last.

**Figure 3:** Boxplots of per quartile distribution of incentives for each of the design options. First row indicates the marginal incentive in terms of an EFT change from a unilateral per country increase of its protected area share by one per cent. The



second row indicates the incentives as a per square kilometer EFT change. Countries are categorized into quartiles according to countries' distances to fulfill the Aichi target of 17 % terrestrial protected areas by 2020. The quartiles are "no gap" for a distance of less 0 up to 1.8, "low" for up to 8.9, "med" for up to 15.2, and "high" for up to 17. The Y-axes of the are log transformed and equal across the three design options per row. Source: authors' elaboration.

### Design choice implications

Distributing a biodiversity fund according to the location of protected areas compensates for past efforts and sets incentives for creating additional protected areas since they become a source of income.<sup>19,21</sup> We contribute the first policy design study on a global intergovernmental fiscal transfer scheme to support biodiversity conservation. The socio-ecological design option allocates the fund such that those countries showing the least progress towards reaching a 17 per cent protected area share by 2020 receive the strongest financial incentive to designate additional protected areas.

Thereby we would expect these countries to have the highest probability to respond to an implementation of the global EFT with increasing their protected area share. The instrument can thus help to reach Aichi target 11. Although Aichi target 11 is one of the few targets that shows sufficient

progress recent contributions argue that humanity needs to protect half the Earth in order to safeguard biodiversity.<sup>37-38</sup> We would thus expect that Aichi target 11 will be increased after 2020. The design choice would still be the same if the distance to 30 or 50 percent was the underlying criterion. Important possible future extensions include biodiversity targeting, directing flows where biodiversity is highest or most threatened, and the inclusion of marine protected areas. But even in its most basic form the instrument would contribute to other Aichi targets than just target 11. It would help to mainstream biodiversity (target 1) into fiscal planning and other policy arenas (target 2) for its intergovernmental fiscal nature. It is an instrument that provides positive incentives for biodiversity conservation (target 3). It would help to reduce the loss of habitats (target 5) and since the less strict protected area categories are taken into account it would also help to ensure sustainable land management (target 7). It also links well with the Nagoya Protocol on ABS (target 16). It would require financial resources to set up an EFT fund at the global level and is thus in line with target 20 on increasing biodiversity financing. Since the largest sums would flow mainly to low income, small island states and to a large extent to African countries, the socio-ecological design does support a fair and equitable distribution of benefits among nations.

The proposed instrument is thus well aligned with the current regime complex for biodiversity protection.<sup>39-41</sup> It furthermore has the benefit of being implemented in similar forms among Brazilian states and in Portugal, such that actual experiences can be further explored and analyzed regarding design principles and outcomes. The main value added by the current proposal, however, consists in the upscaling of an existing instrument for biodiversity conservation to the global level. As such it fills a gap on how ABS mechanisms can be implemented and provides an innovative contribution to the current debates. We would expect that our proposal may serve as a starting point for a more specific science-policy dialogue on benefit and burden sharing of biodiversity conservation between the CBD, the Intergovernmental Platform on Biodiversity and Ecosystem Services, and the broader community.



## **Methods**

This section includes methodological details on: a) the calculation of protected areas per country, b) the construction of a dataset including socio-economic control variables, c) the computation of distributive patterns per design option, d) the computation of distance to Aichi target 11, e) the computation of assessment criteria for design option selection. All source code in both python and R can be found at a personal github repository at: [link to be inserted] such that the results of the analysis are entirely reproducible.

### *(A) Calculation of protected areas per country*

We downloaded the UNEP-WCMC global data set of protected areas from [www.protectedplanet.net](http://www.protectedplanet.net) (version May 2017) as a .gdb file. We used ArcGIS (version 10.4) to compute the share of IUCN protected area categories per country with the following algorithm (based on adapted form of the UNEP-WCMC method): we repaired geometry features for both point and polygon data were repaired; protected areas with statuses 'Not Reported' and 'Proposed' were omitted. We excluded protected areas that are classified as 100 % marine, and point data that had no reported area. The point data was reprojected to World Equidistant Cylindrical coordinate reference system (CRS) (ESRI:54002), points were buffered such that the buffer area matched the reported area and reprojected to World Behrmann CRS (ESRI:54017); polygon data was directly reprojected to World Behrmann CRS; reprojected polygon and buffered point data were merged into a single .gdb. Spatial data on country outlines was obtained from Global Administrative Areas database ([www.gadm.org](http://www.gadm.org)) and reprojected to world Behrmann CRS. For each of the IUCN protected area categories (Ia, Ib, II, III, IV, V, and VI) the corresponding protected areas we dissolved, repaired and iteratively erased from overlaps with former category areas, repaired again, and the country intersection with protected areas was tabulated. Finally, the attributes were exported as a .csv file.

*(B) Construction of a dataset including socio-economic control variables*

The per country IUCN category protected area data was loaded into **R** (version 3.4.1). Only countries party to the CBD were selected (including Greenland). UNDP data on HDI was added from <http://hdr.undp.org/en/data> (2015 data, published 2017). Per country data on population and GDP per capita, PPP (constant 2005 international \$) was downloaded from Worldbank Database through the “**WDI**” package. All these datasets were joined into a single dataframe;

*(C) Computation of distributive patterns per design option*

We used weights for IUCN protected area categories to account for their different contribution to conservation goals based on an adaptation from weights in the Brazilian EFT scheme:  $w=(Ia=1, Ib=0.9, II=0.8, III=0.7, IV=0.5, V=0.3, \text{ and } VI=0.1)$ . The design option payments per country were calculated according to formulas 1-4 in the main text.

*(D) Computation of distance to Aichi target 11*

The distance,  $D$ , was calculated as  $D_i = 17 - \sum_{j=1}^J PA_{ji}$ , for all  $j$  protected areas in per country  $i$ . Countries were then grouped in quartiles according to  $D_i$ .

*(E) Computation of assessment criteria for design option selection*

The marginal incentives per countries were computed as the additional transfer for a unilateral increase of a 1 per cent protected area increase with a probability distribution over IUCN protected area categories corresponding to global average probabilities of the categories. The per square kilometer incentives were calculated as marginal incentive per square kilometer country territory. Both the marginal and per square kilometer incentives were plotted in box plots according to the quartiles of distance to Aichi target 11. The choice was made based upon which design provides the strongest incentives for those countries farthest from Aichi target 11.

## References:

1. Convention on Biological Diversity. 1992. <https://www.cbd.int/>
2. Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity. 2011. <https://www.cbd.int/abs/>
3. Morgera, E., Tsioumani, E., Buck, M., 2014. Unraveling the Nagoya Protocol - A Commentary on Access and Benefit-sharing to the Convention on Biological Diversity. Brill, Leiden. Doi:10.1163/9789004217188
4. Morgera, E., 2016. The need for an international legal concept of fair and equitable benefit sharing. *Eur. J. Int. Law* 27, 353–383. doi:10.1093/ejil/chw014
5. Bonn Guidelines on Access to Genetic Resources and Fair and Equitable Sharing of the Benefits Arising out of their Utilization. 2002 <https://www.cbd.int/abs/bonn/>
6. Oldham, P., Hall, S., Forero, O., 2013. Biological diversity in the patent system. *PLoS One* 8. doi:10.1371/journal.pone.0078737
7. Székely, T., Gaillard, A., 2007. Conserving biodiversity using patent law. *Nat. Biotechnol.* 25, 1087–1088. doi:10.1038/nbt1007-1087
8. Bartkowski, B., 2017. Are diverse ecosystems more valuable? Economic value of biodiversity as result of uncertainty and spatial interactions in ecosystem service provision. *Ecosyst. Serv.* 24, 50–57. doi:10.1016/j.ecoser.2017.02.023
9. Convention on Biological Diversity, Decision X/2. Strategic Plan for Biodiversity 2011-2020, including Aichi Biodiversity Targets. <https://www.cbd.int/decision/cop/?id=12268>
10. Convention on Biological Diversity, Global Biodiversity Outlook 4. A mid-term assessment of progress towards the implementation of the Strategic Plan for Biodiversity 2011-2020. <https://www.cbd.int/gbo4/>
11. Waldron, A., Mooers, A.O., Miller, D.C., Nibbelink, N., Redding, D., Kuhn, T.S., 2013. Targeting global conservation funding to limit immediate biodiversity declines. *Proc. Natl. Acad. Sci.* 110, 1–5. doi:10.5061/dryad.p69t1
12. McCarthy, D.P., Donald, P.F., Scharlemann, J.P., Buchanan, G.M., Balmford, A., Green, J.M.H., Bennun, L.A., Burgess, N.D., Fishpool, L.D.C., Garnett, S.T., Leonard, D.L., Maloney, R.F., Morling, P., Schaefer, H.M., Symes, A., Wiedenfeld, D.A., Butchart, S.H.M., 2012. Financial Costs of Meeting Global Biodiversity Conservation Targets: Current Spending and Unmet Needs. *Science* (80-. ). 338, 946–949. doi:10.1126/science.1229803
13. McClanahan, T.R., Rankin, P.S., 2016. Geography of conservation spending, biodiversity, and culture. *Conserv. Biol.* 30, 1089–1101. doi:10.1111/cobi.12720
14. McKinney, M.L., 2002. Effects of national conservation spending and amount of protected area on species threat rates. *Conserv. Biol.* 16, 539–543. doi:10.1046/j.1523-1739.2002.00442.x

15. Balmford, A., Gaston, K.J., Blyth, S., James, A., Kapos, V., 2003. Global variation in terrestrial conservation costs, conservation benefits, and unmet conservation needs. *Proc. Natl. Acad. Sci. U. S. A.* 100, 1046–50. doi:10.1073/pnas.0236945100
16. Olson, M., 1969. The Principle of “Fiscal Equivalence”: The Division of Responsibilities among Different Levels of Government. *Am. Econ. Rev.* 59, 479–487. doi:10.1126/science.151.3712.867-a.
17. Ring, I., 2008. Biodiversity governance: Adjusting local costs and global benefits, in: Sikor, T. (Ed.), *Public and Private in Natural Resource Governance: a False Dichotomy?* Earthscan, London, pp. 107–126.
18. Loureiro, W., 2002. *Contribuição do ICMS Ecológico à Conservação da Biodiversidade no Estado do Paraná.* Universidade Federal do Paraná, Curitiba.
19. May, P.H.H., Veiga Neto, F., Denardin, V., Loureiro, W., 2002. Using fiscal instruments to encourage conservation: Municipal responses to the “ecological” value-added tax in Paraná and Minas Gerais, Brazil, in: Pagiola, S., Bishop, J., Landell-Mills, N. (Eds.), *Selling Forest Environmental Services: Market-Based Mechanisms for Conservation and Development.* Earthscan, London, pp. 173–199.
20. Ring, I., 2008. Integrating local ecological services into intergovernmental fiscal transfers: The case of the ecological ICMS in Brazil. *Land use policy* 25, 485–497. doi:10.1016/S0921-8009(02)00124-6
21. Farley, J., Aquino, A., Daniels, A., Moulart, A., Lee, D., Krause, A., 2010. Global mechanisms for sustaining and enhancing PES schemes. *Ecol. Econ.* 69, 2075–2084. doi:10.1016/j.ecolecon.2010.02.016
22. Droste, N., Lima, G.R., May, P.H., Ring, I., 2017. Municipal Responses to Ecological Fiscal Transfers – a microeconomic panel data approach. *Environ. Policy Gov.* doi:10.1002/eet.1760
23. Sauquet, A., Marchand, S., Féres, J., 2014. Protected areas, local governments, and strategic interactions: The case of the ICMS-Ecológico in the Brazilian state of Paraná. *Ecol. Econ.* 107, 249–258. doi:10.1016/j.ecolecon.2014.09.008
24. Santos, R., Ring, I., Antunes, P., Clemente, P., 2012. Fiscal transfers for biodiversity conservation: The Portuguese Local Finances Law. *Land use policy* 29, 261–273. doi:10.1016/j.landusepol.2011.06.001
25. Köllner, T., Schelske, O., Seidl, I., 2002. Integrating biodiversity into intergovernmental fiscal transfers based on cantonal benchmarking: a Swiss case study. *Basic Appl. Ecol.* 3, 381–391. doi:10.1078/1439-1791-00104
26. Ring, I., 2008. Compensating municipalities for protected areas: Fiscal transfers for biodiversity conservation in Saxony, Germany. *Gaia* 17, 143–151.
27. Borie, M., Mathevet, R., Letourneau, A., Ring, I., Thompson, J.D., Marty, P., 2014. Exploring the Contribution of Fiscal Transfers to Protected Area Policy. *Ecol. Soc.* 19. doi:10.5751/ES-05716-190109

28. Schröter-Schlaack, C., Ring, I., Koellner, T., Santos, R., Antunes, P., Clemente, P., Mathevet, R., Borie, M., Grodzińska-Jurczak, M., 2014. Intergovernmental fiscal transfers to support local conservation action in Europe. *Z. Wirtschaftgeogr.* 58, 98–114.
29. Droste, N., Ring, I., Schröter-Schlaack, C., Lenk, T. (2017). Integrating Ecological Indicators into Federal-State Fiscal Relations – a policy design study for Germany. *Environmental Policy and Governance* 27(5): 484–499. doi: 10.1002/eet.1774
30. Kumar, S., Managi, S., 2009. Compensation for environmental services and intergovernmental fiscal transfers: The case of India. *Ecol. Econ.* 68, 3052–3059. doi:10.1016/j.ecolecon.2009.07.009
31. Irawan, S., Tacconi, L., Ring, I., 2014. Designing intergovernmental fiscal transfers for conservation: The case of REDD+ revenue distribution to local governments in Indonesia. *Land use policy* 36, 47–59. doi:10.1016/j.landusepol.2013.07.001
32. Droste, N., Ring, I., Santos, R., Kettunen, M., 2016. Ecological Fiscal Transfers in Europe – evidence based design options of a transnational scheme (No. 10–2016), UFZ Discussion Papers. Leipzig.
33. UNEP, 2016, Protected Planet Database. <https://protectedplanet.net/> (version Dec. 2016)
34. GADM, 2016. Database of Global Administrative Areas. <http://gadm.org/> (version Dec. 2016)
35. UNDP, 2017, <http://hdr.undp.org/en/data> (2015 data, published 2017)
36. Worldbank, 2017a, <http://data.worldbank.org/> (2015 data, published 2017)
37. Wilson, E. O., 2016. *Half-earth: our planet's fight for life*. WW Norton & Company.
38. Dinerstein, E., Olson, D., Joshi, A., Vynne, C., Burgess, N. D., et al., 2017. An ecoregion-based approach to protecting half the terrestrial realm. *BioScience*, 67(6), 534–545. doi:10.1093/biosci/bix014
39. Raustiala, K., Victor, D.G., 2004. The Regime Complex for Plant Genetic Resources. *Int. Organ.* 58, 277–309. doi:10.1017/S0020818304582036
40. Rosendal, G.K., 2006. Balancing Access and Benefit Sharing and Legal Protection of Innovations From Bioprospecting: Impacts on Conservation of Biodiversity. *J. Environ. Dev.* 15, 428–447. doi:10.1177/1070496506294799
41. Buck, M., Hamilton, C., 2011. The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity. *Rev. Eur. Community Int. Environ. Law* 20, 47–61. doi:10.1111/j.1467-9388.2011.00703.x

## **Supplementary Information**

The source code and data for the computational analysis can be found at a personal github repository: link – to be inserted later in order not to infringe anonymity

## **Acknowledgements:**

ND is grateful for financial support by the Heinrich-Böll-Foundation (grant. no. P118873) and a Helmholtz Interdisciplinary Graduate School for Environmental Research (HIGRADE) travel grant for his research stay at the Gund Institute for Ecological Economics at the University of Vermont.

## **Author Information:**

### **Affiliations**

UFZ - Helmholtz Centre for Environmental Research, Department of Economics, Permoserstraße 15, 04318 Leipzig, Germany  
Nils Droste, Irene Ring

Martin-Luther University Halle-Wittenberg, Department of Economics, Große Steinstraße 73, 06108 Halle (Saale), Germany  
Nils Droste

FLACSO - Facultad Latinoamericana de Ciencias Sociales, Department of Development, Environment and Territory, Ave. Diego de Almagro, 170201 Quito, Ecuador  
Nils Droste

University of Vermont, Gund Institute for Ecological Economics, Burlington, VT 05405, USA  
Joshua Farley, Taylor Ricketts, Nils Droste

Technische Universität Dresden, International Institute Zittau – IHI, Ecosystem Services, Markt 23, 02763 Zittau, Germany  
Irene Ring

Federal Rural University of Rio de Janeiro – UFFRJ, Department of Development, Agriculture and Society – DDAS, 20071-003 Rio de Janeiro, Brazil,  
Peter H. May

Federal University of Rio de Janeiro, Institute of Economics, Strategies for Sustainable Development, 22290-902 Rio de Janeiro, Brazil  
Peter H. May

### **Contributions**

ND conceived the research, has conducted the computational analyses and written the first draft. JF directed this project. JF and TR hosted ND. IR supervises the larger research project. All authors have equally contributed to mechanism design, evaluation criteria and revision of the original draft.

***Competing financial interests***

The author's declare no competing financial interests.

***Corresponding author***

Correspondence and requests for materials should be addressed to [nils.droste@ufz.de](mailto:nils.droste@ufz.de).