Make nature count; an explorative application of Gross Ecosystem Product and the Ecosystem Stress Index for nature inclusive policymaking

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The benefits provided by ecosystem services, such as crop pollination and water purification, are of great importance to any economy. There is a need to move beyond current measures such as the Gross Domestic Product (GDP) that does not fully capture nature's contribution to the economy and does not factor in environmental impacts. The concept of Gross Ecosystem Product (GEP) which summarizes the value that ecosystem services provide to the economy in monetary terms is a way to overcome these shortcomings in policy assessments.

The strength of GEP lies mainly in the fact that it complements GDP measures. By using the national accounts approach, it provides policymakers with a clear and intuitive indicator of nature's contribution to the economy, based on the ecosystem services considered. The use of GEP alongside other macroeconomic indicators provides a more accurate picture of the impact of policies on the economy and on nature. As is the case for GDP, an evaluation of the underlying components of GEP is useful, such as the aggregated value of ecosystem services for each ecosystem.

So far, ecosystem service valuations and GEP applications have focused a single country or subset of regions (e.g. the EU member states in the INCA database). In this exploratory assessment we aim to incorporate a global GEP dataset, although limited to the forest ecosystems and analyse how the different SSP scenarios are expected to impact the Gross Ecosystem Product with the MAGNET model.

Methods

We use MAGNET, a global general equilibrium model, with recently developed extensions on modelling changes of ecosystem valuations to estimated future development of the GEP as a post-simulation indicator. In earlier work, we have employed the INCA database to project the GEP for EU member states.[1] For the current work, we have added natural capital data from changing wealth of nations 2024 (CWON 2024[2]), particularly for the forestry related ecosystem services, for a global comprehensive picture of changes of ecosystem services valuations. At the current state of the CWON allows a connection of the GEP module to forest related ecosystem services only, other ecosystem services' natural capital calculations have not been included. Thus, we focus presently on the forest related ecosystem services reported in the CWON dataset (namely timber provisioning, recreation and water retention services). This data serves as a starting point for the GEP module, which updates these values using appropriate MAGNET output variables.

In the GEP module in MAGNET, the updates of ESS values are made explicit for both the supply and the demand side. Through this way of updating, it is acknowledged that the MAGNET GEP module lacks the gridded analysis that is often used in ESS valuations methods to match changes in potential

[1] European Commission, Joint Research Centre, Rokicki, B., M'barek, R., Grammatikopoulou, I., La Notte, A., Van Alphen, M., Van Zeist, W., Bartelings, H. and Polman, N., Gross Ecosystem Product in macroeconomic modelling, Publications Office of the European Union, Luxembourg, 2024, https://data.europa.eu/doi/10.2760/57602, JRC138106.
[2] https://www.worldbank.org/en/publication/the-changing-wealth-of-nations

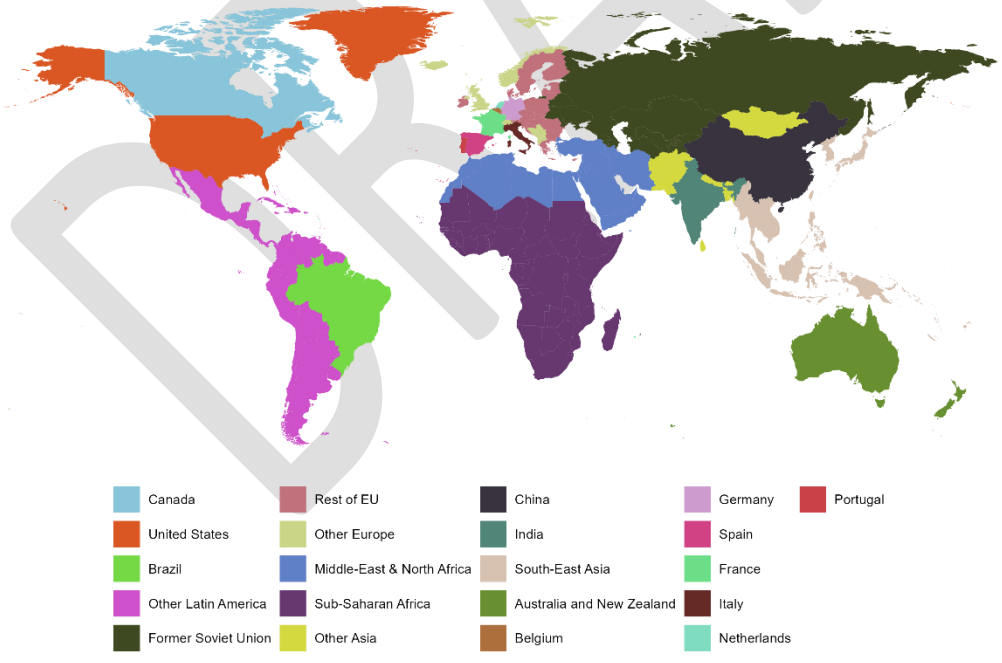
supply and demand.[3] Despite this obvious limitation, this approach can still create insight in how both demand and supply changes might potentially lead to a higher stress or over-utilization of the ecosystem service. For example, in the case of water retention services, the supply side is updated based on the land cover changes of agricultural, forestry, and unmanaged forest, presuming that the delivery of ecosystem services per hectare of ecosystem remains stable. From the demand side an update statement is included reflecting changes in GDP, as more assets are presumed to be at risk of flooding as GDP increases.

Constructing a supply and demand side of the ES valuation allows to analyse the balance between demand and supply and the 'stress' on the Ecosystem service (ESS) if demand increase more rapidly than supply. Thus, below a 'ESS stress index' is added which is defined as follows, and starts with a value of 100 in the base year:

ESS stress index = 100 * ESS Demand / ESS Supply

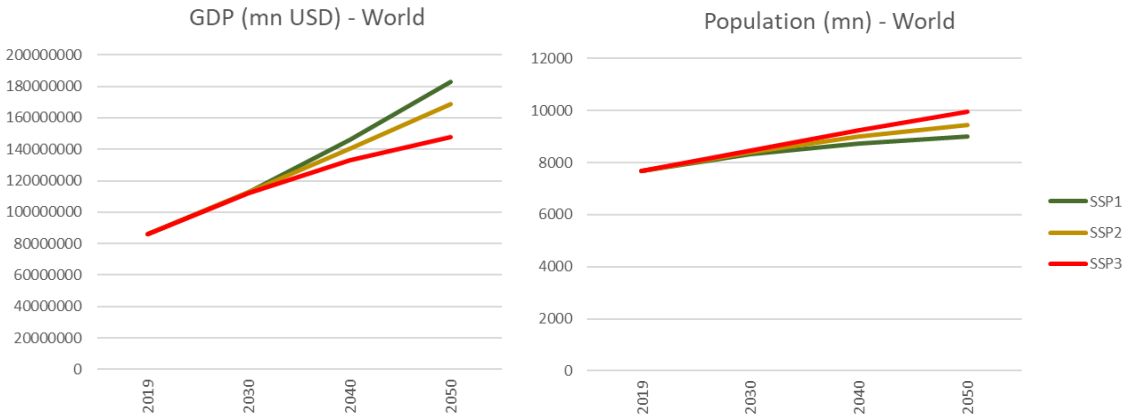
Scenarios

For this exercise the SSP v3.0 GDP and population paths were applied in MAGNET scenarios running up to 2050, with a regional aggregation as shown below. The SSP2 follows business as usual principles, whereas SSP1 follows 'green growth' assumptions with higher GDP and productivity. SSP3 is a more challenging scenario with higher population but lower GDP growth and less focus on sustainability or climate targets.



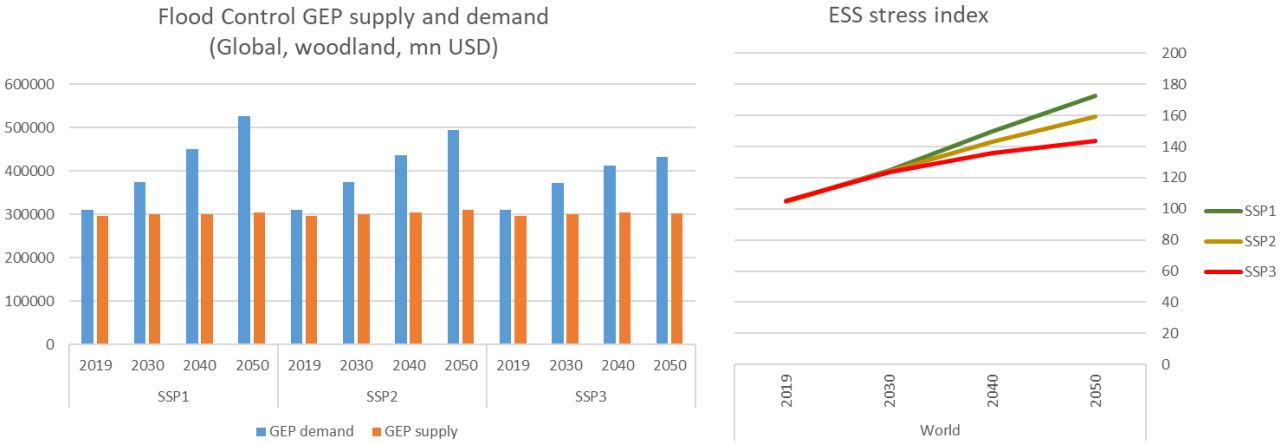
[3] Vallecillo et al. Accounting for changes in flood control delivered by ecosystems at the EU level, Ecosystem Services, Volume 44, 2020, 101142, https://doi.org/10.1016/j.ecoser.2020.101142

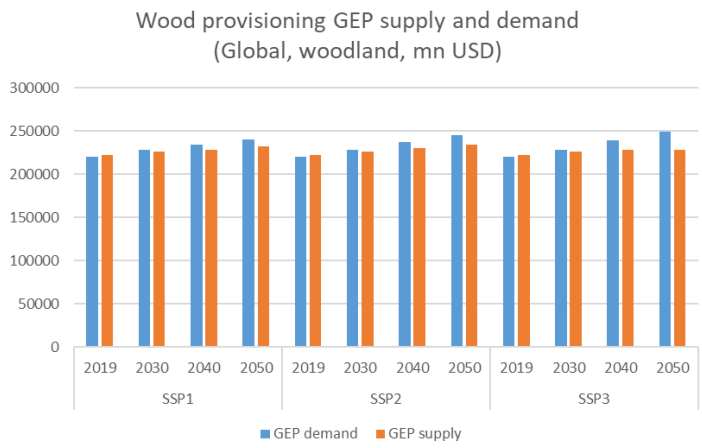
Global drivers for population and GDP are shown below, highlighting key differences between GDP and population growth dynamics.

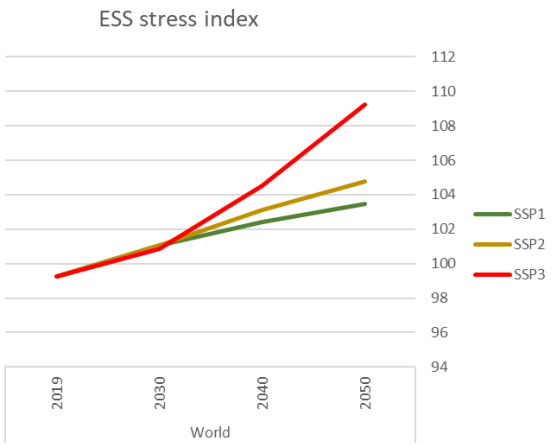


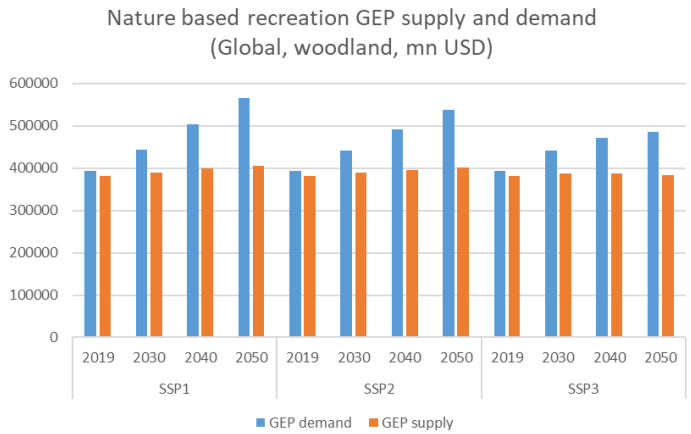
Results

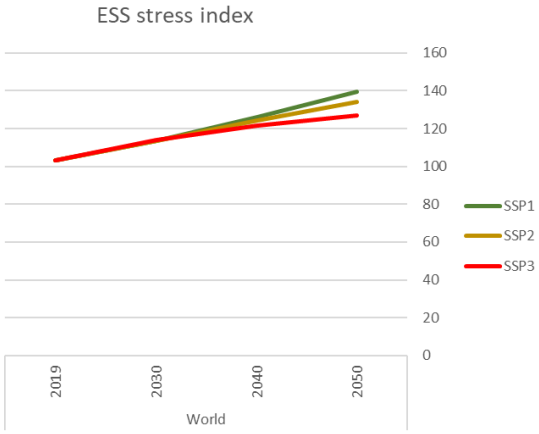
For the water retention ecosystem service (or flood control service) part of the GEP calculation, the results in terms of supply and demand are shown in the graph below. As explained above, in both the supply and demand values the starting point is the monetary value data for the ecosystem services provided by the CWON 2024 report. This shows that demand of the flood control increases as GDP increases (largely dependent on the SSPs GDP path). At the same time, the supply is fairly stable, as the MAGNET model projections do not include large changes in total forest cover. The balance is such that demand still outpaces supply and the 'stress' on the ecosystem service increases steadily. This effect is stronger for the SSP1 scenario, which assumes higher GDP growth compared to SSP2, and vice-versa for SSP3. For the nature-based recreation service the pattern is similar, with the projected increase of the recreational sector driving demand outpacing the supply from land use changes. In the wood/timber provision related part of the GEP, the overall ESS stress index also increases due to higher demand which is met partially for more intensification (i.e. more capital and fuel input) of the managed forests. In this case the stress index rises fastest for SSP3, where less area dedicated to forest reduces the supply side whereas the demand side is met through more intensive production with more fossil fuel inputs.











Future work

Applying the CWON 2024 figures as in the MAGNET GEP module is a simplification, and work is currently undergoing to improve representation of various ecosystem services on a global level using value transfer functions based on analysis of the Ecosystem Services Valuation Database (ESVD). Thus, we hope to continuously expand the representation of the GEP on a global coverage. On the other hand, on a country level different topics are of greater importance, and work is ongoing in creating a GEP dedicated for the Netherlands, using the Dutch Natural Capital Accounts as a starting point.

In the analysis of the changes of ES over time, we aim to include footprint analysis of ecosystem services connected to production sectors (e.g. the timber provisioning services) to gain insight on a region's dependence of ecosystem services in other regions due to trade relations.