4. SPECIAL ISSUES

4.1. TAKING INTO ACCOUNT THE KEY ROLE OF NATURAL CAPITAL FOR ECONOMIC ACTIVITY

Introduction

Natural resources are a recurrent topic in the European Economic Forecasts, mostly given that temporary scarcities of mineral resources (oil, gas) or agricultural commodities [39] affect the near-term outlook on prices and production. Concerns have been voiced that demand for critical minerals may outpace supply in the medium-term [40]. In this special topic, we take a broader view of the interaction between the economy and nature. The overuse of natural resources — such as energy, forests, water and land - in economic activities may lead to a degree of depletion of natural resources and degradation of ecosystems that threatens key inputs upon which economies depend. This is already happening - the emission of greenhouse gases persistently beyond the natural absorption capacity of ecosystems has now caused an increase in the frequency of natural disasters, which further weakens ecosystems' capacity to provide critical services. Recognizing this interaction between economic activity and nature is crucial for fostering sustainable economic growth.

Although the classical economist considered land as a production factor, and the concept of 'natural capital' has been employed in environmental economics for decades, standard contemporary macroeconomic models continue to abstract from the interactions between natural assets and the economy, and they are only partly captured by traditional measures of economic output [41]. Against the background of increasing environmental concerns, efforts have been stepped up to better measure the contribution of the environment to the economy and the impact of the economy on the environment. While in the past, macroeconomic modellers and macroeconomists advising policymakers have generally shown limited interest in natural capital accounting, this is changing rapidly. Recent policy initiatives and discussions on the economic importance of natural capital have been undertaken by the OECD (2021), the World Bank (2021), the Coalition of Finance Ministers for Climate Action (2022), monetary policy makers (e.g. Boldrini et al 2023) and the White House (2023) [42].

Building on the Autumn 2023 Forecast special issue on the impact of extreme weather events on national accounts and the European Economic Forecasts, this special topic is part of a series of analytical contributions that look into the sustainability of economic output from different angles, with a view to broadening the scope of European Economic Forecasts and the economic surveillance they underpin. After laying out the interactions between natural capital and the

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(39) For instance, the possible impact of El Nino conditions on crops was discussed in the 2023 Summer and Autumn forecasts.

(40) International Energy Agency (IEA) (2023). *Critical Minerals Market Review 2023*, Paris, IEA, December.

(41) See for example Dasgupta, P. (2021). The Economics of Biodiversity: The Dasgupta Review. London, HM Treasury. World Bank (2021). The Changing Wealth of Nations 2021: Managing Assets for the Future. Washington, DC, World Bank Group.

(42) Organisation for Economic Cooperation and Development (OECD) (2021). "Biodiversity, natural capital and the economy: A policy guide for finance, economic and environment ministers", *OECD Environment Policy Papers*, No. 26, Paris, OECD Publishing. Johnson, J., G. Ruta, U. Baldos, R. Cervigni, S. Chonabayashi, E. Corong, O. Gavryliuk, J. Gerber, T. Hertel, C. Nootenboom and S. Polasky (2021). *The Economic Case for Nature, A global Earth-economy model to assess development policy pathways.* Washington D.C., World Bank Group,. Power, S., N. Dunz and O. Gavryliuk (2022). *An Overview of Nature-Related Risks and Potential Policy Actions for Ministries of Finance: Bending The Curve of Nature Loss.* Coalition of Finance Ministers for Climate Action, Washington, D.C. Boldrini, S, A Ceglar, C Lelli, L Parisi and I Heemskerk (2023). "Living in a world of disappearing nature: physical risk and the implications for financial stability", *ECB Occasional Paper* 333. The White House (2023). "Accounting for Ecosystem Services in Benefit-Cost Analysis". Online briefing.

economy, the analysis focuses on the measurement of these interactions and discusses modelling approaches to depict them [43].

The interactions between natural capital and the economy

The United Nations (2020) [44] defines natural capital as: "[..] the stocks of environmental assets (including natural resources, ecosystems and a stable climate) that generate flows of goods and services into the economy."

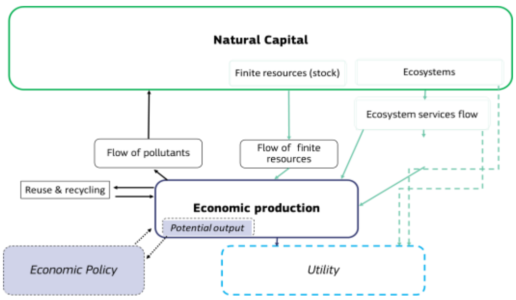
Natural assets can be classified as *finite resources* and *ecosystems* (cf. Dasgupta 2021). Finite resources, including minerals, fossil fuels, and metals, are non-renewable. They are exploited by extractive industries and used as inputs to various industrial processes, including energy production and infrastructure development. Ecosystems, in contrast, encompass diverse biological communities and their physical environment, such as forests, wetlands, oceans, and grasslands, which provide a vast array of vital ecosystem services. They enable the regeneration of renewable resources (e.g. crops, animal feed, fish and timber) and contribute directly to economic production with the provision of clean air, water and soil fertility. Ecosystems also provide climate regulation and mitigate natural hazards such as landslides, flooding, or wildfires. Finally, beyond providing goods and services that can be valued economically, ecosystems crucially support life and contribute to human well-being, for example through the availability of breathable air and other health benefits, as well as benefits of non-economic value (e.g. the aesthetic value of an unspoiled landscape).

Natural capital interacts with the economy in various ways (see for example Bastien-Olvera and Moore 2021 [45] and Graph I.4.2). Essentially, as economic activity crucially relies on natural capital, it leads to the depletion of finite resources and generates material residuals that enter the environment as waste or polluting emissions. For example, deforestation to make way for agriculture or urban development can contribute to climate change. Over-fishing damages marine ecosystems and biodiversity. Restoration and preventive efforts – like reforestation, erosion control and limitations to carbon pollution – can to some extent limit or prevent the costs of economic activity on natural capital.

Quantifying the interaction between natural capital and the economy

Quantifying the interaction between natural capital and economic activity is key in order to design optimal policies that reconcile economic growth with environmental sustainability. To this purpose, the United Nations developed the System of integrated Environmental and Economic Accounts (SEEA) [46] which enables countries to combine economic and environmental data using a common set of concepts, definitions, classifications and accounting rules. The aim of this framework is to provide a more comprehensive view of the interrelations between the economy and the environment, and the stocks and evolution of environmental assets. The EU contributed significantly to this endeavour through the Knowledge Innovation Project on Integrated Natural

Graph I.4.1: **Feedback loops between natural capital and economic production**



[43] See also Döhring, B., A. Hristov, A. Thum-Thysen, and C. Carvello (2023). "Reflections on the Role of Natural Capital for Economic Activity", *European Economy-Discussion Papers* 180, Brussels, EC, February.

[44] United Nations (2020). *Natural Capital Accounting For Sustainable Macroeconomic Strategies,* New York, Department of Economic and Social Affairs.

[45] Bastien-Olvera, B and F Moore (2021). "Use and non-use value of nature and the social cost of carbon", *Nature Sustainability* 4: 101-108.

[46] United Nations (2014). System of Environmental-Economic Accounting 2012 — Central Framework. New York. United Nations (2021). System of Environmental-Economic Accounting — Ecosystem Accounting. New York.

Capital Accounting (INCA), jointly undertaken by the European Commission and the European Environment Agency (see Vysna et al 2021; Bagstad et al 2021 [47].

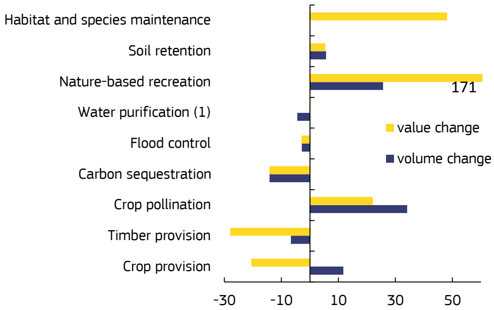
Based on the SEEA accounting principles, Eurostat's "Environmental Economic Accounts" (EEA) organise environmental data from many domains using the same concepts and terminology as the national accounts, in both physical terms - to record flows of materials from, to and within the economy - and monetary terms - to record, e.g. environmental taxes and subsidies. To date, only part of the SEEA is implemented, and work remains in progress, in particular accounting for ecosystem services.

Focussing on inputs to economic activity and services to humans, the SEEA does not reflect all the intrinsic values of natural capital as it so far only covers a subset of nature's assets. Whereas resources traded in markets are covered by the system of national accounts, many ecosystem services do not have a market price and remain thus invisible in standard metrics of economic production (e.g. the pollination of orchards or carbon storage in forests and wetlands). Outside the boundaries of the national accounts techniques have been developed in the SEEA and EEA to measure the quantity and quality of ecosystems and the flow of ecosystem services they produce. For the monetary valuation, the SEEA and EEA use methods that are as close as possible to those in use in the national accounts [48].

Using the INCA data on ecosystems, Graph I.4.2 illustrates that the contribution of a number of ecosystem services to the EU economy has been on a downward trend over the past two decades. These include most of those ecosystem services that are a direct input to economic activity or those whose absence constitutes a risk to economic activity. Although the surface of agricultural land in the EU has decreased, and the forest surface increased somewhat, the value of both crop and timber provisioning services has dropped sharply in real terms. The volume and value of carbon sequestration and flood control have also decreased, while the strongest increase in value concerns recreation services (which do not include tourism) and habitat & species maintenance.

Another valuable approach to measure the sustainability of economic development is provided by the World Bank in their "Changing Wealth of Nations" report. The corresponding database covers a large set of countries across the globe and uses concepts that are fully compatible with national accounts. It allows exploring a nation's wealth, taking into account not only what is made by people (produced capital) but also the wealth embedded in people themselves (human capital), and – importantly - the wealth offered by nature (natural capital). As such, this wealth accounting system stresses that natural and human forms of capital are intrinsically linked and deserve joint consideration with a view to promoting sustainable prosperity.

Graph I.4.2: **Ecosystem services in the EU (change 2018 compared to 2000 in %)**



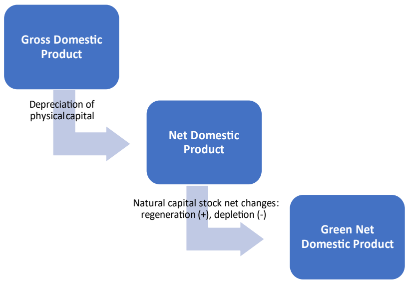
Source: European Commission INCA and AMECO, own calculations.
Notes: Water purification change since 2006. No volume data for habitat and species maintenance. Values in constant (2000) euros.

(47) Vysna, V., J. Maes, J.E. Petersen, A. La Notte, S. Vallecillo, N. Aizpurua, E. Ivits and A. Teller (2021). Accounting for ecosystems and their services in the European Union (INCA). Final report from phase II of the INCA project aiming to develop a pilot for an integrated system of ecosystem accounts for the EU. Statistical report. Luxembourg, Publications office of the European Union. Bagstad, K., J. Carter Ingram, C. Shapiro, A. La Notte, J. Maes, S. Vallecillo, F. Casey, P. Glynn, M. Heris, J. Johnson, C. Lauer, J. Matuszak, K. Oleson, S. Posner, C. Rhodes and B. Voigt (2021). "Lessons learned from development of natural capital accounts in the United States and European Union", Ecosystem Services 52: 101359.

(48) adapted market prices, replacement cost and avoided damage for, e.g. the indirect use value of pollination, soil retention and flood control; effective carbon prices compiled by the OECD as well as willingness to pay for the non-use value of carbon sequestration and habitat/species maintenance respectively.

Data on the stocks of natural capital such as the World Bank's can be used to assess sustainability by observing the development of natural assets alongside the dynamics of economic output. A further step is to link them formally in an extended concept of net domestic product (Graph I.4.3). Green net domestic product is derived from GDP by taking into account the depreciation of fixed capital (net domestic product) as well as the changes in the stock of natural capital due to depletion, destruction and regeneration (cf. Barbier 2019 and for a -partial- implementation the dataset by Skare et al. 2021) [49].

Graph I.4.3: **Green net domestic product**



Source: Adapted from Barbier (2019)

Main avenues for modelling the contribution of natural capital to the economy

The increasing relevance of the interactions between natural capital and economic activity for policy making as well as the development of new integrated environmental economic accounts are spurring initiatives to incorporate the environmental dimension in economic models. The focus here will be on efforts to integrate natural capital into tools for macroeconomic surveillance, in particular the models used for the estimation and projection of potential output [50].

There are different possibilities for modelling the role of natural capital in economic output or wellbeing. The modelling approaches developed so far differ in terms of granularity, coverage of different types of natural assets and representation of the feedback loop between economic activity and natural capital.

At a high level of detail, ecological models that describe one or several ecosystem services in their geographical context are linked to highly disaggregated economic models through input-output relationships (see for example La Notte et al 2020 [51]. Some, such as Johnson et al 2023 [52], have an explicit feedback loop covering the economic pressures on nature and the impact of natural asset degradation on the economy.

In the climate-economic literature, it is standard to model the feedback loop involving greenhouse gas emissions from economic activity and the economic damages resulting from increasing temperatures at a high level of aggregation in integrated assessment models (IAMs). Only few authors have attempted to broaden the scope of climate IAMs to cover also natural capital, e.g. Bastien-Olvera and Moore (2021) [53]. Their model highlights the impact on the economy both directly from climate change and via the damage that rising temperatures causes to natural capital.

Simpler aggregate models employ a macroeconomic production function augmented with natural capital. This approach could be integrated with existing methodologies for production function-

(49) Barbier, E B (2019). "The concept of natural capital", *Oxford Review of Economic Policy* 35(1): 14-36. Skare, M.; D. Tomic, D. and S. Stjepanovic (2021), *Greening' the GDP: A New International Database on Green GDP 1970-2019*, Mendeley Data, V1, doi: 10.17632/24vbg29y48.1.

(50) See the overview of a workshop organised jointly by the Commission (DG ECFIN and Joint Research Centre) and the Economic Policy Committee's Output Gap Working Group: Croitorov, O., B. Döhring, C. Maier, K. Mc Morrow, and A. Thum-Thysen (2024). "The models used to inform policy are lacking natural capital", *VoxEU column*, CEPR, January.

(51) La Notte, A., A. Marques, D. Pisani et al. (2020). Linking accounts for ecosystem services and benefits to the economy through bridging (LISBETH) – Natural capital accounts and economic models – Interaction and applications, Publications Office of the European Union, 2020.

(52) Johnson, J A, U Lantz Baldos, E Corong, T Hertel, S Polasky, R Cervigni, T Roxburgh, G Ruta, C Salemi and S Thakrar (2023). "Investing in nature can improve equity and economic returns.", *Proceedings of the National Academy of Sciences of the United States of America* 120(27) e2220401120.

(53) Bastien-Olvera, B and F Moore (2021). "Use and non-use value of nature and the social cost of carbon", *Nature Sustainability* 4: 101-108.

based potential output estimation (as for example Havik et al 2014) [54] and used to underpin macroeconomic surveillance. Climate change, and more in general the degradation of natural capital, can affect all the drivers of potential output: fixed capital, labour and total factor productivity (TFP) (Parker 2023 [55]. It has already been shown that TFP is incorrectly specified in a production function that does not explicitly include natural capital (Cárdenas Rodriguez et al 2023; Thia et al 2024 [56]. Dasgupta (2021) specifies an extended production function in which the flow of resources and the flow of ecosystem services are made explicit.

$$Y = AS^{\beta}K^{a}H^{b}R^{1-a-b}$$

where Y, K and H denote production, produced physical capital and labour, respectively, with their corresponding elasticities *a* and *b*. *R* denotes natural resource flows, *S* the natural capital stock and S^{β} ecosystem services. *A* denotes total factor productivity. A production function specified in this way is used and elaborated further in Bastien-Olvera et al (2024) [57].

This simple production function framework could be extended firstly by exploring the effects of limited substitutability of natural capital by other assets. Such an extension would build on a wide literature that highlights the difficulty of making economic production sustainable when some inputs are essential, i.e. hard to substitute, [58] and more recent work that shows that substitution possibilities can evolve over time [59].

A second extension would be to also specify the evolution of the stock of natural capital – a key element to capture regeneration and depletion of natural capital assets and to provide insights on the sustainability of the production process. This would be a step towards a more complete coverage of the feedback loop between the economy and natural capital, and thereby rejoining the IAM modelling strand.

Conclusion (The use case)

Assessing the environmental sustainability of economic activity would help broaden the scope of the GDP-centred measure of economic prosperity and help policy makers design optimal policies. As the depletion and degradation of natural capital will affect future economic possibilities, it will become increasingly important to reflect this in the tools that are used to project potential output over the medium term, and that underpin macroeconomic surveillance.

However, the available data do not yet cover the full range relevant for aggregated macroeconomic assessments; they are incomplete, and modelling is challenging even in simplified frameworks. It is unlikely that a single model will prove sufficient, and it is much more probable that a suite of tools will evolve for handling different policy questions.

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(54) Havik, K., K. Mc Morrow, F. Orlandi, C. Planas, R. Raciborski, W. Roeger, A. Rossi, A. Thum-Thysen and V. Vandermeulen (2014). "The Production Function Methodology for Calculating Potential Growth Rates & Output Gaps", *European Economy Economic Papers* 535.

(55) Parker, M (2023). "How climate change affects potential output", *ECB Economic Bulletin* 6/2023.

(56) Cárdenas Rodríguez, M, F Mante, I Haščič and A Rojas Lleras (2023). "Environmentally adjusted multifactor productivity: Accounting for renewable natural resources and ecosystem services", *OECD Green Growth Papers* No. 2023-01. Thia, J.P., X. Kong and J. Su (2024). "Do unpriced natural and ecosystem capital affect economic output? Growth regression analyses", *Sustainable Development* 2024, 1-18.

(57) Bastien-Olvera, B.A., M.N. Conte, X. Dong, X. et al. (2024). "Unequal climate impacts on global values of natural capital", *Nature* 625, 722–727.

(58) This link between sustainability and substitution was already stressed by Dasgupta, P. and G. Heal (1974). "The Optimal Depletion of Exhaustible Resources", *The Review of Economic Studies*, Vol. 41, Symposium on the Economics of Exhaustible Resources, 3-28.

(59) Acemoglu, D. P. Aghion, L. Bursztyn and D. Hemous (2012). "The Environment and Directed Technical Change", *American Economic Review* 102(1), 131–166. Hassler, J., P. Krusell and C. Olovsson (2021). "Directed Technical Change as a Response to Natural Resource Scarcity", *Journal of Political Economy* 129(11), 3039-3072.

Already today, data collected by Eurostat and the World Bank allow to juxtapose the evolution of economic output and the evolution of natural capital, or to calculate an approximation of green net domestic product. Policymakers should take into account these already available insights; this would foster a much-needed awareness of the sustainability of economic production.