

Green GDP

Valuation of the water environment since 1990

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Conference of the Danish Environmental Economic Council 2022

The research project '*Developing and Implementing Green National Accounts and the Green GDP*' is lead by Peter Birch Sørensen (UCPH/ECON) and funded by KR Foundation and the Carlsberg Foundation.

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Green GDP: The Water Environment

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- 1 Motivation and framework
- 2 Project overview
- 3 Examples of stated preferences
- 4 Preliminary results and discussion

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└ Outline

- 1 Motivation and framework
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"The welfare of a nation
can scarcely be inferred
from a measurement of
national income"

Simon Kuznets, 1934

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└ Motivation and framework

└ Limitations of GDP

Limitations of GDP

"The welfare of a nation
can scarcely be inferred
from a measurement of
national income"

Simon Kuznets, 1934

MOTIVATION (1)

While Simon Kuznets' was in charge of developing the concept of GDP in the 1930s, he warned that (...).

"The welfare of a nation can scarcely be inferred from a measurement of national income"

Simon Kuznets, 1934

GDP has become synonymous with welfare despite not capturing:

- 1 The value of the consumption of ecosystem services.
- 2 The value of social factors.

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└ Motivation and framework

└ Limitations of GDP

Limitations of GDP

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GDP has become synonymous with welfare despite not capturing:

- 1 The value of the consumption of ecosystem services.
- 2 The value of social factors.

MOTIVATION (2)

Nonetheless, GDP has largely become synonymous with welfare - which has led to criticism of its shortcomings in not capturing either (1) or (2).

Therefore, there is a widespread search for alternative measures

- e.g. the European Commission has launched a **Beyond GDP initiative**, motivated as being *"about developing indicators that are as clear and appealing as GDP, but more inclusive of environmental and social aspects of progress. Economic indicators such as GDP were never designed to be comprehensive measures of prosperity and well-being."*

Why calculate a Green GDP?

Our estimation of a **Danish Green GDP** serves a triple purpose:

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└ Motivation and framework

└ Why calculate a Green GDP?

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TRIPLE PURPOSE

As a solution to the first shortcoming of GDP,
we estimate a Danish Green GDP with a triple purpose:

Why calculate a Green GDP?

Our estimation of a **Danish Green GDP** serves a triple purpose:

- 1 Valuation allows summation and comparison of ecosystems.

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└ Motivation and framework

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Why calculate a Green GDP?

Our estimation of a **Danish Green GDP** serves a triple purpose:
• Valuation allows summation and comparison of ecosystems.

PURPOSE (1)

1. Beyond just describing the water quality in biological terms, monetary (...) and indicates the WTP for improvements in a given ecosystem relative to consumption of conventional goods.

Why calculate a Green GDP?

Our estimation of a **Danish Green GDP** serves a triple purpose:

- 1 Valuation allows summation and comparison of ecosystems.
- 2 Analyze whether economic development from 1990-2020 meets the criterion of "strong" sustainability?

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PURPOSE (2)

- 1.
2. Neither GDP nor the Green GDP should be interpreted as a measure for welfare, but the Green GDP is the attempt to (...) i.e. whether growth happened at the expense of the overall environment or allowed for a positive net growth in the environmental quality?

Why calculate a Green GDP?

Our estimation of a **Danish Green GDP** serves a triple purpose:

- 1 Valuation allows summation and comparison of ecosystems.
- 2 Analyze whether economic development from 1990-2020 meets the criterion of "strong" sustainability?
- 3 Provide a measure that is directly comparable to the GDP.

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PURPOSE (3)

- 1.
- 2.
3. doing so using a measure that is directly comparable to the familiar concept of the GDP.
 - Alternatively, one could simply use **Genuine Saving** but it's a less known concept which is already included as a component of the Green GDP - which moreover includes the **current benefit** of the environmental quality.

Why calculate a Green GDP?

Our estimation of a **Danish Green GDP** serves a triple purpose:

- Valuation allows summation and comparison of ecosystems.
- Analyze whether economic development from 1990-2020 meets the criterion of "strong" sustainability?
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Conventional Net National Income:

$$\mathbf{NNI} = \text{GDP} - \text{depreciation of manufactured capital} \\ + \text{net foreign factor income}$$

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└ Motivation and framework

└ Research framework

Research framework

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FRAMEWORK (1)

In the literature, the Green NNI is the preferred measure, while one can deduct the Green GDP from it.

The **NNI** can be written as (...):

i.e. the NNI captures the annual output of Danish citizens both domestically and abroad before accounting for the environment.

Conventional Net National Income:

$$\text{NNI} = \text{GDP} - \text{depreciation of manufactured capital} \\ + \text{net foreign factor income}$$

Green Net National Income:

$$\text{GNNI} = \text{NNI} + \text{benefit of the environmental quality} \\ + \text{net growth in the environmental quality}$$

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Research framework

Conventional Net National Income:

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Green Net National Income:

$$\text{GNNI} = \text{NNI} + \text{benefit of the environmental quality} \\ + \text{net growth in the environmental quality}$$

FRAMEWORK (2)

The **Green NNI** is defined as:

NNI

- +current marginal benefit of the environmental quality
- +present value of net growth in environmental quality

[In more general terms - *only if asked*]

- +value of consumption of environmental services
- +value of saving in environmental assets

Part 1: Panels of ecological status

Construct complete panels of ecological status for 1990-2020 comprising every Danish waterbody.

Constructing a panel dataset:

- 1 Biologists' field observations with GPS coordinates.
- 2 Assign point observations to matching water bodies.
- 3 Impute missing observations
 - Estimated by *multivariate imputation by chained equations (MICE)* where a *fully conditional specification (FCS)* is constituted by a conditional density for each year.
 - Physical characteristics are included in a *Bayesian ridge regression* using *iteratively-reweighted regularized least-squares*.
- 4 Extrapolation of ecological status of streams for 1990 and 1991.

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- Extrapolation of ecological status of streams for 1990 and 1991.

Our contributions are twofold.

PART 1

(...) i.e. for all streams, lakes, fjords, coastal waters and ground-water bodies. DGP:

1. ... apply the conservative approach of using the observation that indicates the worst quality.
2. ... included in the latest Danish waterbody plan.
3. ... the reason is that data isn't representative but has a systematic overrepresentation of larger waterbodies and those of special concern for the ecological quality.
4. ... by estimating a linear trend and using it to predict.

Part 2: Apply valuation studies

Shadow prices measured by the marginal current benefits of improving the quality of the Danish water environment on a national level.

I.e. the marginal willingness to pay using stated preference studies:

- **Surface waters:** Meta regressions analysis of 32 nordic studies (Zandersen et al, *pending*, DCE Technical Note).
- **Ground water:** *Choice experiment* with only 383 respondents around Limfjorden with overrepresentation of women and higher educated (Larsen et al, 2020, IFRO Working Paper).

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Example 1: Characteristics of ground water quality

Three different ground water quality levels are distinguished: *Good, Moderate and Poor*. The differences between these levels are described below. The water can always be used for irrigation no matter the quality level.

Ground water quality	Description of water quality
Good	The water quality is <u>not</u> affected by pollution from human activity The water can be used for drinking following <u>minimal</u> treatment
Moderate	The water quality is <u>slightly</u> affected by pollution from human activity The water can be used for drinking following <u>minimal</u> treatment
Poor	The water quality is <u>very</u> affected by pollution from human activity The water can be used for drinking following more <u>comprehensive</u> treatment

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- └ Examples of stated preferences
 - └ Example 1: Characteristics of ground water quality

EXAMPLE 1:
Description of the expected ground water quality following different policy proposals.

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Example 2: Choice set for ground water quality

Choice situation 1

	Current policy	Proposal 1	Proposal 2
Expected water quality	Poor	Moderate	Good
Risk of water quality not improving	No water quality improvement	40 % risk of not improving water quality	No risk (Water quality will improve as expected)
Water quality is achieved in	8 years	50 years	8 years
Tax increase for your household	\$0 per year	\$15 per year	\$105 per year

I prefer (If you find the proposals too expensive relative to the resulting improvements, you should choose the current policy)

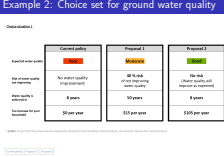
Current policy Proposal 1 Proposal 2

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Examples of stated preferences

Example 2: Choice set for ground water quality



EXAMPLE 2:

Marginal willingness to pay per household is deduced from elaborate questionnaires such as the one containing this choice set regarding different proposed policies to improve ground water quality.

The quality of ecosystem services has improved from 1990-2020.

If $\Delta\text{GNNI} > \Delta\text{NNP} \Rightarrow$ GDP underestimated growth since 1990.

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└ Preliminary results and discussion

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Preliminary results and discussion

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PRELIMINARY RESULTS AND DISCUSSION

Overall, the quality of ecosystem services has improved since 1990.

That is likely to be offset by the costs of GHG emissions and the depletion of exhaustable natural resources

- but if it should turn out that $\Delta\text{GNNI} > \Delta\text{NNP}$,

\Rightarrow then it would indicate that GDP growth has not been at the expense of the environment according to the definition of "strong" sustainability.

That is, with reservations that we don't fully live up to our international commitment such as the EU Water Framework Directive and the GHG reduction path implied by the Paris Agreement DESPITE outsourcing of our most polluting factories during the period.

The quality of ecosystem services has improved from 1990-2020.

If $\Delta GNNI > \Delta NNP \Rightarrow$ GDP underestimated growth since 1990.

Comprehensive robustness checks are necessary.

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ROBUSTNESS

To construct an unbroken time series, we need to only rely on test methods for ecological and chemical quality that has been applied since the early 90s while applying so-called "heroic assumptions", thus

\Rightarrow *Comprehensive robustness checks are necessary*

some of which will have to be "back-of-the-envelope" calculations.