Green Net Domestic Product

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Session 2: Applied natural capital measures

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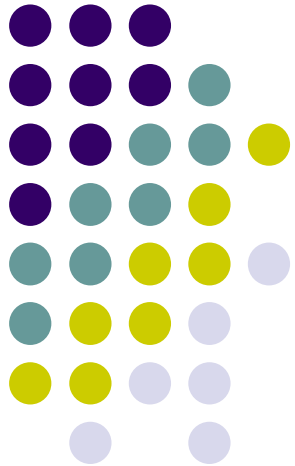

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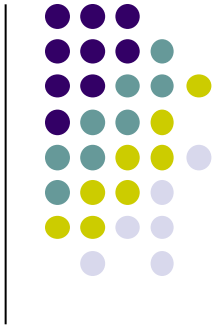
Overview

- Economic wealth
  - Physical, human and natural capital
  - Ecological capital
- Adjusted (green) NDP, economic wealth and sustainability
  - Accounting for human and natural capital
  - Accounting for ecological capital
  - Measuring ANDP
- Accounting for ecological capital losses



Economic Wealth

Physical capital
Dwellings, factories, structures, equipment, inventories, consumer durables, etc.

Human capital
The skills, education and health embodied in the workforce

Natural capital
Land, forests, fossil fuels, minerals, fisheries

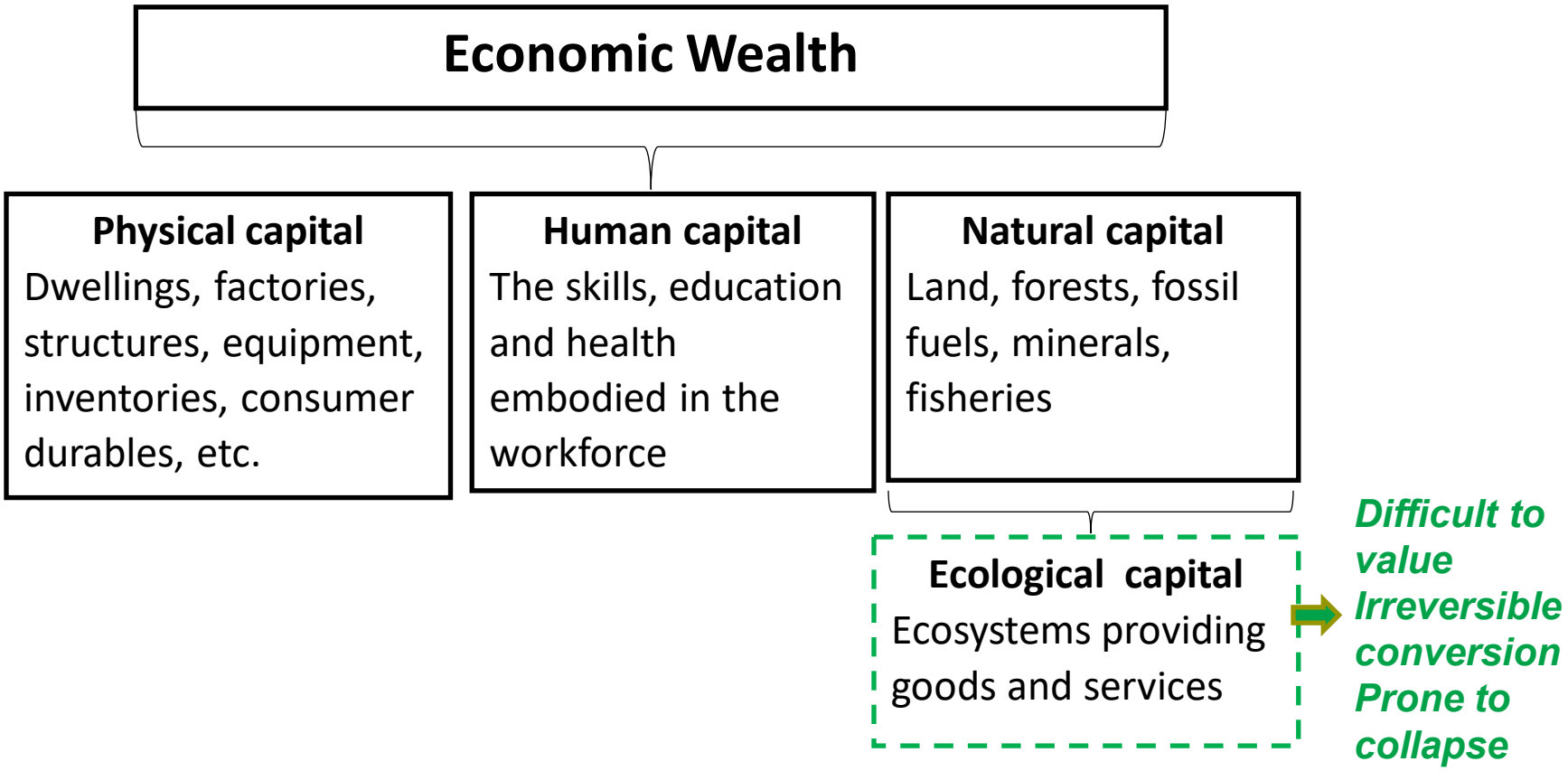
Declines with current production and use

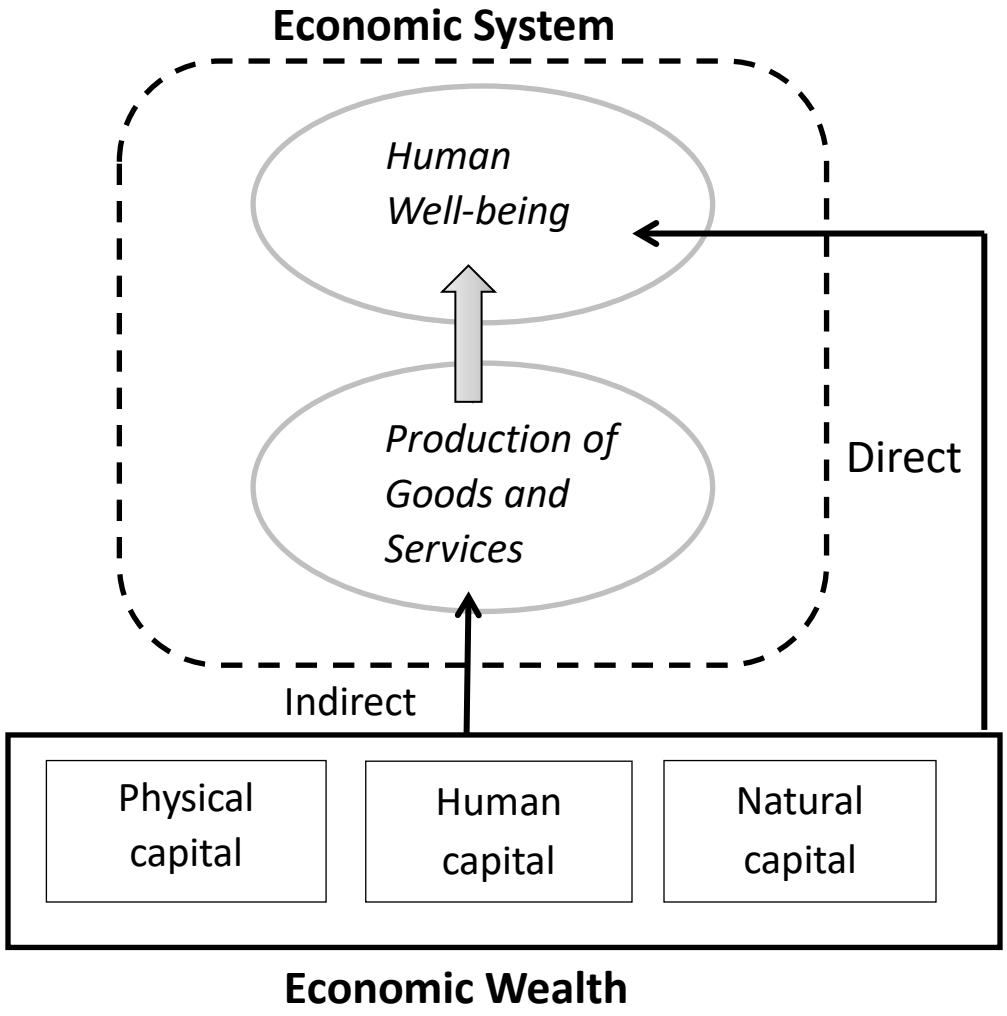
Build up other economic assets

Re-invest revenues earned from natural resource exploitation

Ecological capital

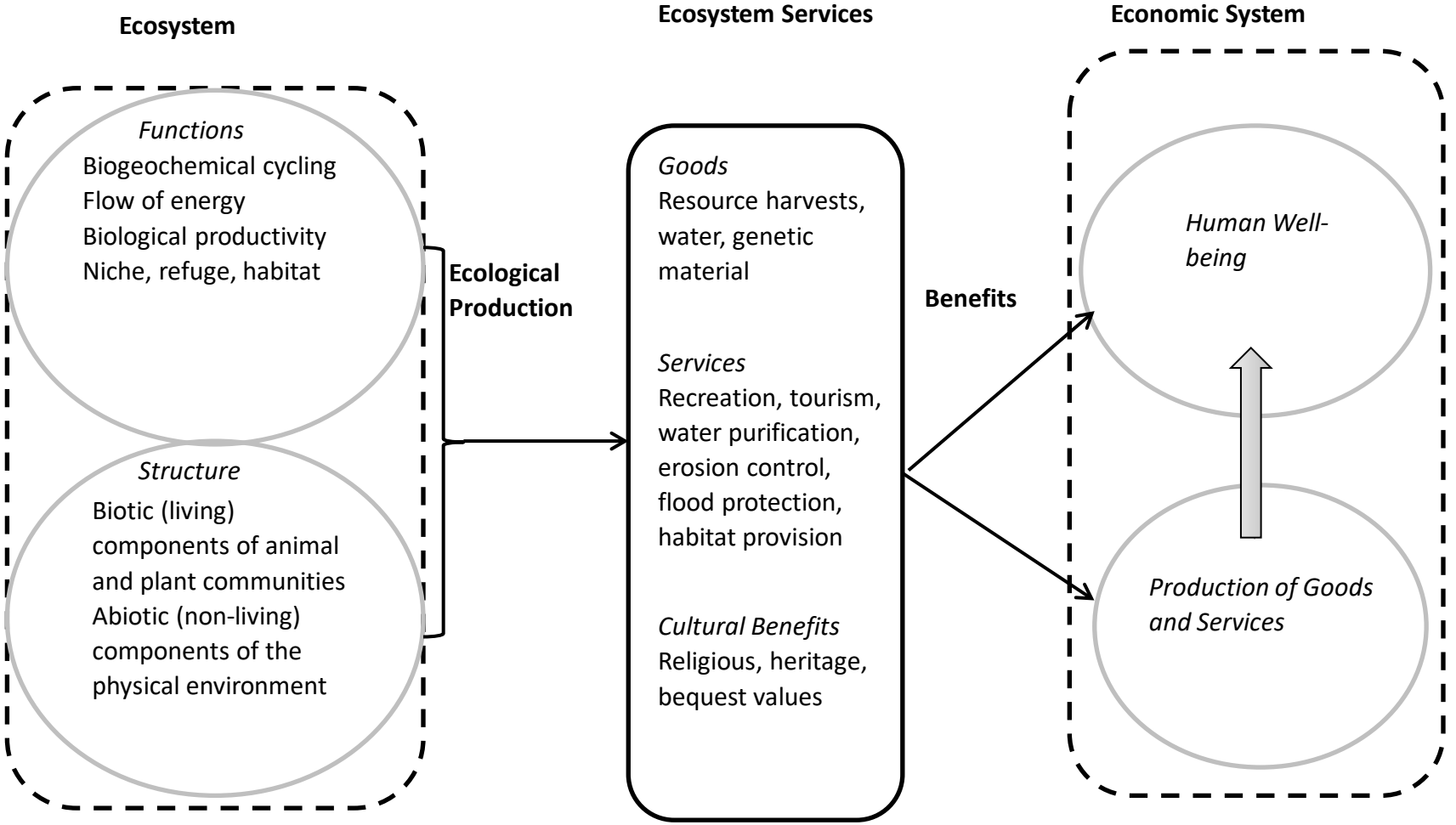
- Depletable asset (conversion/degradation) with renewable services (benefits)
- Most ecosystems and their services are not marketed.
- Capitalized value of ecosystems not reflected in market prices





Physical, human and natural capital either directly support current and future well-being or do so indirectly through contributing to current and future production of goods and services in an economy. Thus, these three assets comprise the economic wealth of a country

How ecosystems generate economic benefits



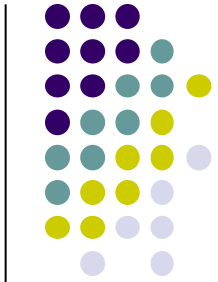
Including ecosystem services in NDP

- NDP is the market value of all final goods and services (GDP) less any (net) depreciation in capital.
- If any goods and services produced from the current stock of ecosystems are *marketed or are intermediate inputs into marketed production*, then NDP will most likely already reflect their current contribution.
  - Ecosystem services, such as waste management, habitat support, storm protection, flood mitigation, groundwater recharge, often serve as intermediate inputs in marketed economic production activities or protect marketed assets (e.g. property).
  - Some goods obtained from ecosystems, such as harvested raw materials, water supplies, food, fiber and fuel, are marketed or are processed by industries into marketed products.
- To add these ecosystem service values to NDP would result in double counting.

Ecosystem conversion and NDP

- NDP must also account for any capital revaluation in the economy that occurs when ecosystems are converted to other land uses.
  - The depreciation of a natural asset – ecosystems – is partly compensated for the appreciation of another asset – more land for economic production and development.
  - NDP must account for the loss in the capitalized value of ecosystems net of the gain in the capitalized value from the additional developed land created through such conversion.
- In this case, the capitalized value of converted ecosystems must reflect the present value of all foregone future benefits of these ecosystems, whether they influence welfare directly or indirectly through production of marketed final goods and services.

Accounting for human and natural capital



- Conventionally defined NDP is GDP adjusted for depreciation in the value of physical capital only (consumption of fixed capital).
- NDP should also be adjusted for any net gain (or loss) in human capital from current investments in education, training or health.
- NDP should also account for net changes in the value of natural capital arising from
  - The current depletion of non-renewables (fossil fuels, minerals).
  - Any net gains or losses for renewable resources, such as forests and fish, depending on whether depletion exceeds biological growth.

Accounting for ecological capital

- NDP should be adjusted to include two contributions due to ecological capital:
  - the value of the (unmarketed) *direct benefits* provided by the current stock of ecosystems, and
  - any capital revaluation as a result of conversion of ecosystems to other land uses, with the "price" of changes in ecological capital reflecting the present value of the future *direct and indirect benefits* of ecosystems.
- If there is a risk of ecosystem collapse due to ecological degradation or conversion, then NDP should also be adjusted for the direct benefits and capital revaluation consequences of that risk.
- If there is any ecological restoration, NDP should also be adjusted for the gain in ecosystem benefits, subject to the risk of ecological failure.

Arrow-Dasgupta inclusive wealth framework

- See Barbier (2016) for details and proofs.
- Defining at time *t* a shadow price $v^i(t)$ for each asset *i* of the economy, its aggregate, or *inclusive*, wealth $W(t)$ is

$$W(t) = v^K K(t) + v^H H(t) + v^Z Z(t) + v^N N(t) + v^D D(t)$$

Physical capital | Human capital | Natural resource stocks | Ecosystems | Developed land

- Investment $I(t)$ at time *t* is

$$I(t) = v^K \dot{K} + v^H \dot{H} + v^Z \dot{Z} + \underbrace{v^N \dot{N} + v^D \dot{D}}_{\left(v^D - v^N\right)c}$$

- For any net increase in developed land at the expense of ecosystems $\dot{N} = -c(t) = \dot{D}$

Inclusive wealth and sustainability

- Define U_C as the price of consumption in "utils" (utility flow), and U_N as the price of ecosystem goods and services that directly influence well-being. Then aggregate NDP is

$$NDP(t) = U_C C(t) + U_N N(t) + I(t)$$

- Letting $V(t)$ represent intergenerational well-being at time t

$$V(t) = V\left(K(t), H(t), Z(t), N(t), D(t)\right), \frac{dV(t)}{dt} = I(t)$$

- Thus sustainability implies

$$dV(t)/dt \geq 0 \text{ iff } NDP(t) \geq U_C C(t) + U_N N(t)$$

- As long as NDP exceeds the value of consumption and ecosystem goods and services, intergenerational welfare will not decline.
- Conventional NDP should be "adjusted" for all changes in aggregate *inclusive* economic wealth, $W(t)$.

Adjusted NDP and wealth accounting

- Adjusted NDP (ANDP) is

$$ANDP = NDP + \left(v^H h(E) - v^K E\right) + v^Z \left[G(Z) - R\right] + U_N N + \left(v^D - v^N\right) c$$

Conventionally measured

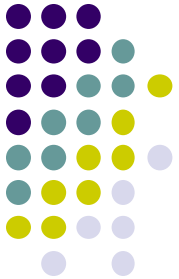
Value of changes in human capital

Value of net natural resource depletion

Direct benefits of current ecosystems

Capital gains (depreciation) From net ecological conversion

- If there is a risk of ecological collapse, then ANDP must be modified by:
  - Changes in all the shadow prices *v* due to the risk of failure
  - Direct benefits of current ecological capital must be weighted by the probability of the current stock of ecosystems surviving.
  - Any capital revaluation as a result of conversion of ecosystems to other land uses must be adjusted for the change in the risk of collapse caused by such conversion.



Gross Domestic Product (GDP)

- Market value of all final goods and services

Net Domestic Product (NDP)

- GDP less depreciation of physical capital (consumption of fixed capital)

Conventional Economic Indicators

Adjustments for changes in human capital

- Net gain or loss in human capital from education, health and training investments

Adjustments for changes in natural capital

- Net changes in renewable and non-renewable natural resource stocks

Adjustments for changes in ecological capital

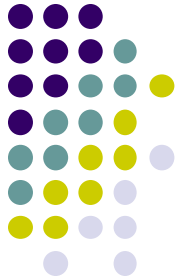
- Value of the direct benefits provided by the current stock of ecosystems and any capital revaluation due to ecosystem conversion or restoration

Adjusted NDP

Applying ANDP: Challenges

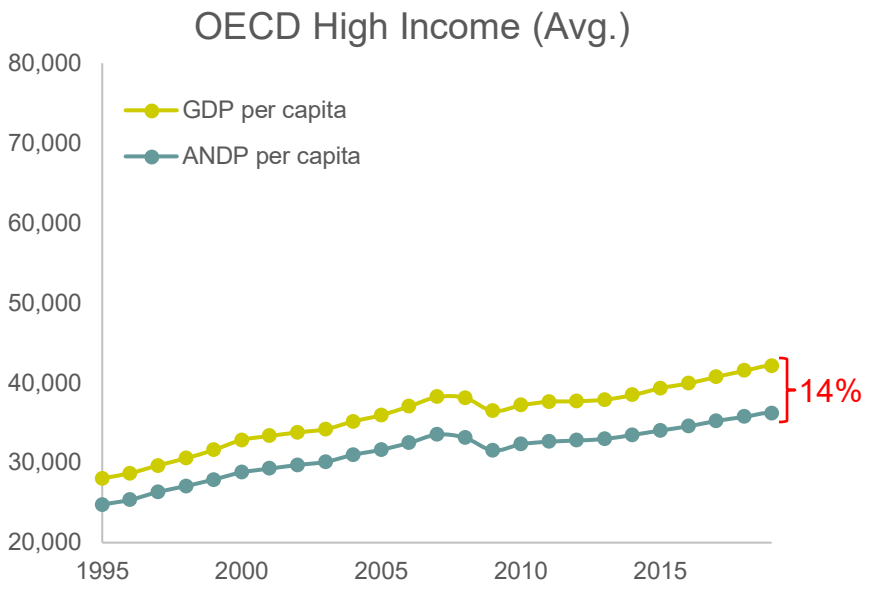
- Can use WDI to obtain a limited ANDP measure.
  - Fossil fuel, minerals and timber depreciation.
  - Education expenditures a proxy for human capital investment.
  - No ecological capital or services.
- Although WA and IWR measures include additional natural and ecological capital, difficult to use for ANDP.
  - Any ecosystem service values include marketed and non-marketed contributions.
  - Not easy to estimate capital revaluation from conversion of ecosystems to other land uses.

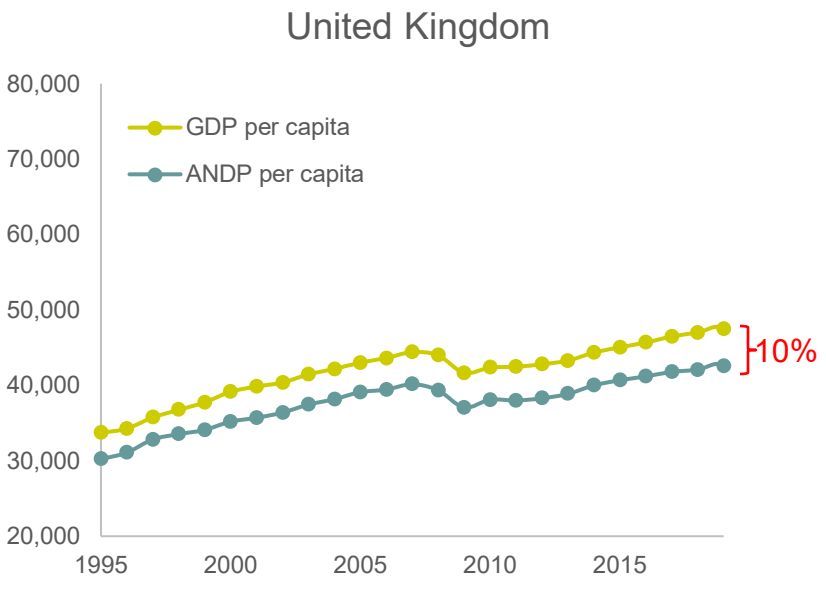
Applying ANDP: Advantages

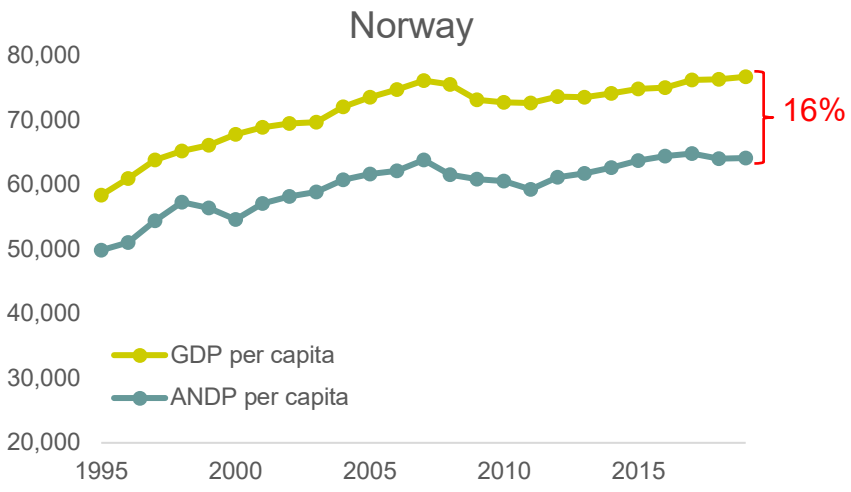


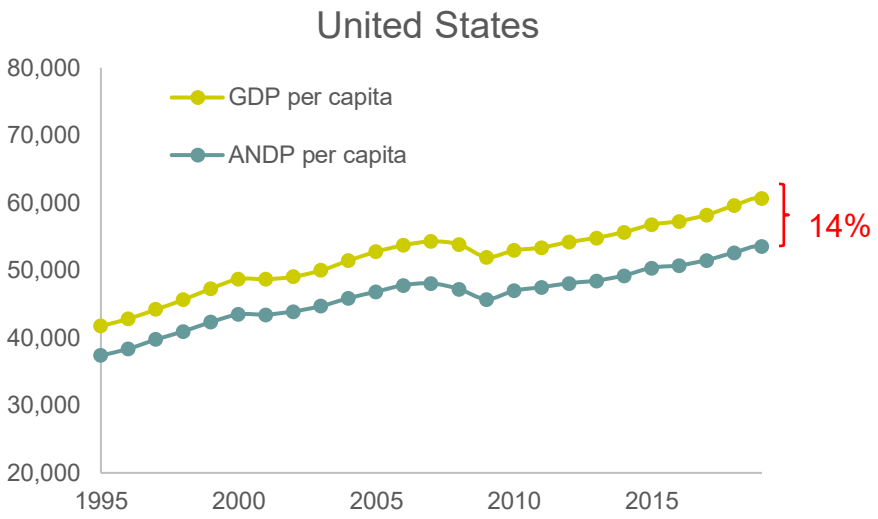
- Even a limited ANDP measure using WDI can provide extremely useful insights.
  - Especially important for countries that are highly dependent on mineral and energy wealth.
  - Can identify how well countries are creating wealth net of natural capital depreciation (Barbier 2019).
- Rather than adjust NDP for all types of natural and ecological capital, it might be more useful to use the ADNP method to account for ecological capital losses.
  - Mangrove loss in Thailand 1970-2009 (Barbier 2016).

GDP per capita vs ANDP per capita, high-income OECD, 1995-2019









Adjusted net domestic product (ANDP) is equal to GDP plus education expenditure and minus consumption of fixed capital and natural resource depletion (constant 2015 US$). Natural resource depletion is the sum of net forest depletion, energy depletion, and mineral depletion. Source: WDI

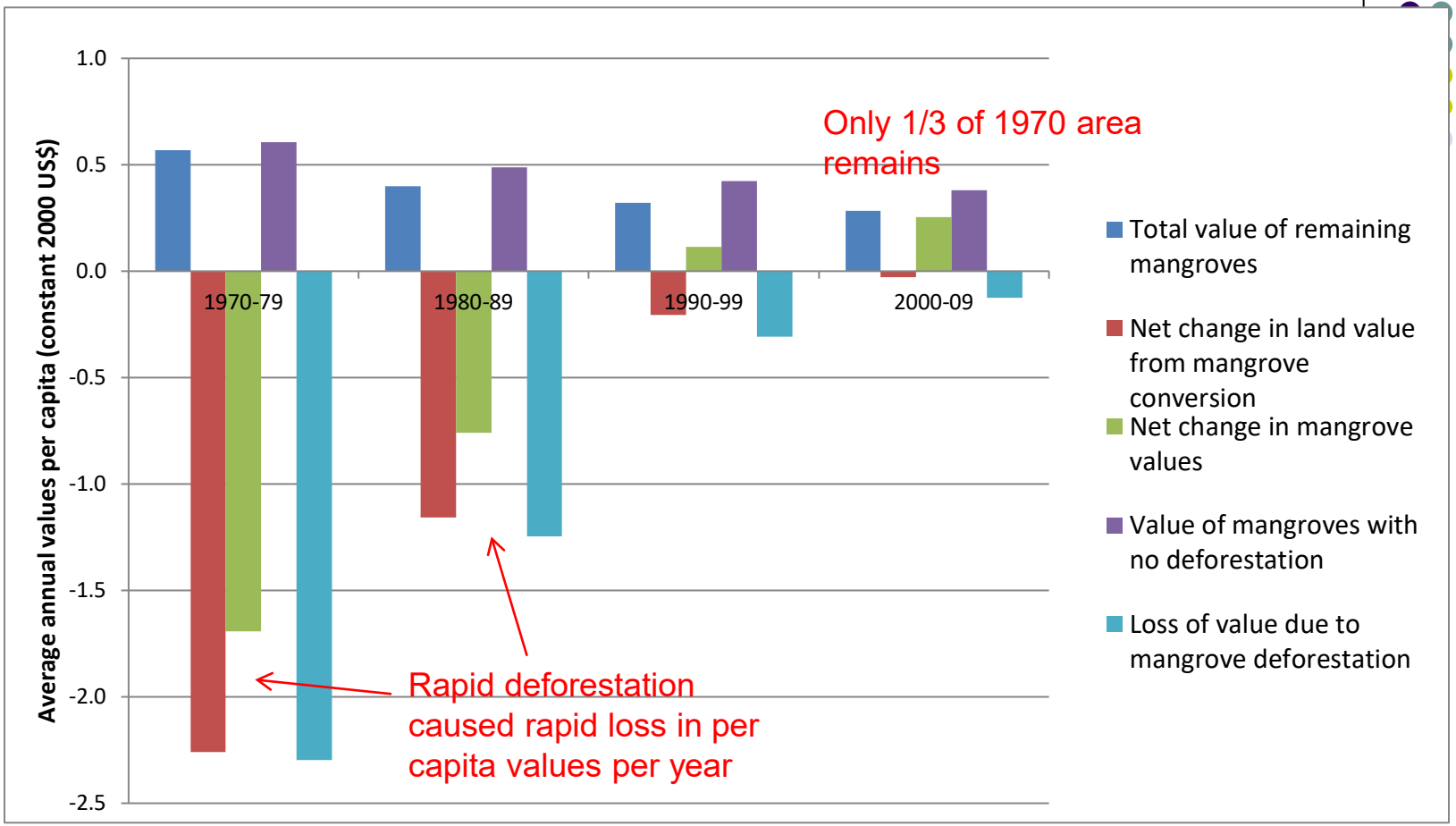
Accounting for ecological capital losses

- It may be useful to estimate the overall economic losses due to ecosystem conversion that are not estimated by conventional income accounting.
- This can be done be estimating a key component of ANDP:

$$\underbrace{U_N N(t)}_{\text{Direct benefits of current ecosystems}} + \underbrace{\left[v^D(t) - v^N(t)\right] c(t)}_{\text{Capital gains (depreciation) From net ecological conversion}}$$

- The sum of these two components represent the net gain or loss in ecological capital values, and when compared to the value of ecosystem assets if no conversion occurred, one can obtain the overall loss or gain in the value of ecological capital.

Accounting for Mangrove Capital, Thailand, 1970-2009



Value of mangroves with no deforestation assumes that mangrove area remains unchanged since 1970. The total value of mangroves in 1970 was $25.2 million (constant 2000 US$) and the population of Thailand was 36.9 million. The decline in per capita values over 1970-2009 is therefore due to population growth. Based on the annual losses from deforestation, the total per capita losses in Thailand from mangrove deforestation from 1970 to 2009 amount to $39.79 per person (constant 2000 US$). Based on the 2009 population of 68.7 million, the total cumulative losses from mangrove deforestation from 1970 to 2009 are over $2.73 billion (constant 2000 US$). **Source: Barbier (2016), *ARRE***

Final remarks

- Green (adjusted) NDP is an important indicator of how "sustainable" is our current production of marketed goods and services.
- Even a limited ANDP measure using WDI data for (marketed) natural capital is a useful indicator.
- Extending ANDP to account for (unmarketed) ecological capital is difficult.
- ANDP approach still useful for estimating the overall economic losses due to ecosystem conversion that are not estimated by conventional income accounting.