# Natural Capital and Economic Growth

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## 1. Introduction

A growing economy is a cornerstone of conventional thinking about successful development. Ensuring that any given economy is on (and remains on) this path necessitates an understanding of the economic growth process.[2] Typically, this will emphasise the (net) accumulation of a diverse portfolio assets within the economy. Changing technological possibilities are also focal to this story enabling the frontier of what can be achieved with accumulated economic resources to expand over time. In this short note, the role that natural capital[3] plays in this process is discussed:

First, it explores some of the possible implications of unsustainable use of natural capital for economic growth prospects. This, in turn, is discussed from two perspectives; one which is relatively optimistic about possibilities for substitution (which emphasises how much saving an economy is doing on balance) and another perspective which is less optimistic (and emphasises what is happening to natural assets). Illustrations for the UK indicate that on neither perspective do sustained development prospects look encouraging and part of the reason for this is what is a growing deficit in natural capital;

Secondly, given a programme to reverse this natural capital deficit – such as the 25 Year Plan proposed by the Natural Capital Committee (NCC, 2015) – possible pathways to enhancing economic prospects are outlined using some illustrative cases entailing investment in natural assets. In a number of these cases this could lead to a significant

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[2] See, for example, Jones and Vollrath (2013).

[3] Defined as "… elements of nature that produce value or benefits to people (directly and indirectly), such as the stock of forests, rivers, land, minerals and oceans as well as the natural processes and functions that underpin their operation" (NCC, 2013).

boost to the measured economy particularly, for example, where it enhances other productive assets such as human capital.

The rest of this note is organised as follows. Section 2 reviews a possible framework for exploring the relationship between natural capital and economic growth and uses existing empirical observations to draw some related inferences for the UK. Section 3 discusses some possible growth benefits from investing in natural assets along the illustrative lines proposed in NCC (2015). Section 4 concludes.

## 2. Unsustainable use of natural capital and economic growth

Researchers have identified a large number of pathways through which natural capital influences economic growth.[4] The basic building block in determining growth prospects are the assets that the economy holds (or can make use of).[5] This asset base includes produced capital (i.e. machinery, buildings and physical infrastructure) and human capital (i.e. the education and health of the population). It also includes natural capital; a diverse portfolio of non-renewable and renewable assets provided by the natural environment. Some asset stocks comprise an infrastructure thereby forming the basic foundations on which growth prospects are built. These growth pre-requisites can be tangible such as in the case of physical infrastructure. They can also include intangible assets – notably social institutions and rules – governing economic relationships and organisation.

Output (or income) in the economy can be thought of as the return on these assets.[6] Typically, this return refers to some accounting aggregate for the measured economy: e.g. summarised by "GDP".[7] This has the advantage of being enshrined in the statistical standards of the UN System of National Accounts (SNA) but it circumscribes what is judged

[4] This includes shifting the economy to a higher level output or affecting its growth rate, through the provision of natural capital benefits or by influencing other growth determinants including the rapidity of technological change (see, for reviews and discussion, Ricci, 2007; Hallegatte et al. 2012; Smulders and Withagen, 2013; Smulders *et al*. 2014; Bowen, 2015). Another emerging tradition looks alternatively at development prospects through asset accounting including what is happening to natural capital (see, for example, Hamilton and Hartwick, 2014; Mayer, 2014; Hamilton, 2014).

[5] That is, 'make use of' could refer to assets outside of the country that ultimately it enjoys benefits as a result of continued provision. In the case of natural assets, this might refer to globally shared assets such as climate stability or the stratospheric ozone layer or critical assets (such as tropical forests and other hotspots of biodiversity) within or across other countries.

[6] See, for a discussion on the interpretation of the relation between national income and production accounts and national balance sheet, Hamilton (2014).

[7] That is some measure of national income or output such as Gross Domestic Product either in total or on a per person basis or perhaps some more specific measure of consumption.

as a return.[8] For some assets perhaps this does not matter; that is, the contribution of these assets can almost exclusively be understood in terms of what appears (implicitly or explicitly) in GDP.

For natural capital, however, this is surely an issue (although one of extent). An illustration of this is provided by the natural capital found in land assets (e.g. as represented by habitat types). Some of the benefits provided by these assets undoubtedly show up in GDP. For example, the UK's tourism satellite account published by the Office for National Statistics (ONS) indicates that this sector contributes annually about 4% to GDP. This contribution can be viewed, in part, as a return on these natural assets given the importance of landscape and natural features as an (implicit) input in a good deal of tourism activities. Nevertheless, the return on these assets is likely to be far greater than what shows up in GDP. Unless there is a compelling reason for favouring output generated in the measured economy (i.e. "GDP" or "SNA benefits"), consideration of this broader return or output is important both now and in understanding what might increasingly matter to people as the economy evolves over time.[9]

To recap, output in the economy (narrowly or broadly defined) can be interpreted as the return on the assets that this economy possesses or uses. A shrinking asset base might then imply declining output and so lower growth prospects. Of course, the composition of these assets are changing over time along a development path. For example, natural capital inputs might be in decline because these assets themselves are being used unsustainably. If these resources remain essential to future production then this could place a drag on growth (given that fewer and fewer inputs of this type are available).[10] Whether this will be the case could depend on the ease with which these increasingly scarce resources can be substituted for other assets. If the potential for substitution exists then this is one means by which the drag on growth implied by unsustainable *use* of natural capital need not translate into unsustainable *development*.

[8] For example, even if expressed on a per capita basis, it does not reveal how much of this income is ultimately enjoyed by households. Generally speaking, GDP records the value of (final) goods and services subject to market transactions as well as the costs of providing government services.

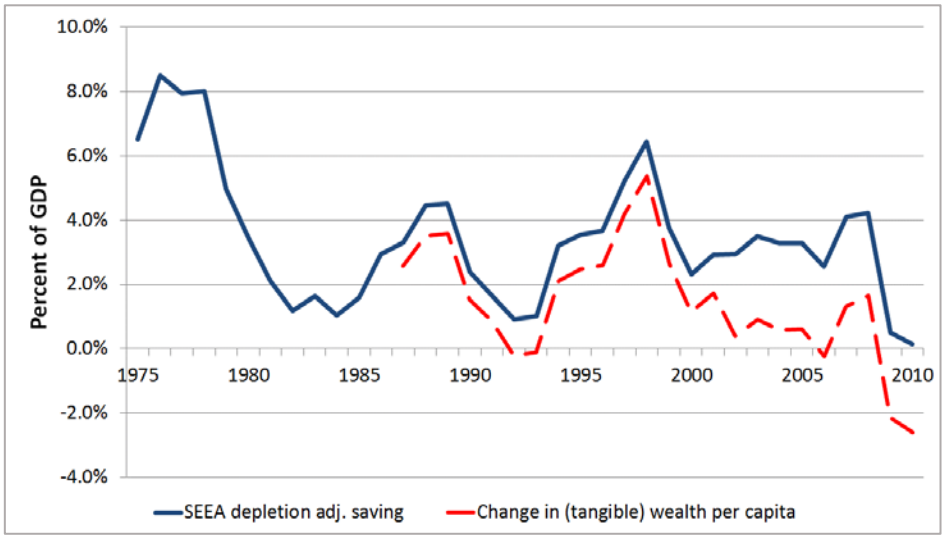
[9] Of course, this information is also important for conducting cost-benefit analyses. Commonly, this empirical record in these appraisals of natural capital benefits does not distinguish between values which are likely to show up in GDP and those which do not. However, such information would be useful for understanding how these assets underpin the economy.

[10] That is, less output can be generated from these natural capital inputs and the productivity of produced assets also used in production is also diminished (Smulders and Withagen, 2013).

Even if this were the case, what is happening to assets in the economy overall remains important. For the UK, for example, this gives a picture which is far from reassuring. A good starting point for illustrating this is the new UN System of Environmental and Economic Accounts or SEEA statistical standard: 'depletion-adjusted net saving'. This deducts from gross saving[11] the depreciation of produced capital. It also deducts the depletion of sub-soil assets (e.g. particularly oil and gas resources).

Figure 1 plots this depletion-adjusted saving measure for the UK from 1975 to 2010. This saving measure is positive but only just above 0 for at least some of this period. Notably, this is the case for the early 1980s when the value of resource depletion was at its highest (relative to GDP) as well as in the early 1990s. Notable also is the drop in the net saving rate in the final two years illustrated in the figure (and overall an average rate for 2001 to 2010 of only 3% of GDP).

**FIG. 1: UK (Tangible) Wealth from 1975 to 2010**




Source: adapted from Atkinson and Hamilton (2015)

Depletion adjusted saving is a measure of the *total* change in tangible assets in the economy. It is useful also to look at the change in *per capita* wealth. This measures the extent to which total assets are shared over a changing population. From 2001-2010, in the UK, population growth was in the vicinity of a moderate 0.5% per year on average. Yet

[11] The gross saving rate for the nation is a broad measure of how much any nation is saving for the future and is simply the residual of what is left over once consumption has been subtracted from the nation's income or output. In the case of the UK, for example, this saving rate averaged just below 15% (of GDP) over the period 2001 to 2010 (and just under 17% from 1975 to 2010). While positive, this is a *gross* measure of assets being accumulated and so it does not take into account those assets which are used up and depreciated in the course of generating an income flow.

relatively low rates of depletion-adjusted saving suggests that even this moderate increase might have implications for how much the rate of net saving per capita.

In Figure 1, this estimate goes back to 1987 when UK balance sheets for produced assets commence. The change in this tangible wealth (i.e. the change in produced assets plus sub-soil natural assets, net of wealth dilution caused by population change) stays positive until 2008 after which it is negative. The disparity between depletion adjusted saving and this measure is also notable after 2000. That is, there is a growing difference between how much the UK is saving, on balance, *in total* and how much is being saved on a *per capita basis* (given that accumulated assets are being shared across a larger population).

Overall it appears that the UK has a low net savings rate (based on this UN Statistical Standard) such that the sustainability of growth can be queried. This conclusion needs further scrutiny both in terms of what it currently measures (and importantly what it does not) and the assumptions on which this measure is premised.

With regards to the former, missing items such as education expenditure (if added in) would lead to more favourable conclusions. Clearly, however, Figure 1 describes an incomplete picture of what is happening to natural assets. The impacts of poor air quality provide one illustration of this. One recent study, for example, estimates that in 2010, the value of the health damage in the UK from exposure to particulate matter (i.e. PM2.5) alone could lie in the range of 4% to 6% of GDP.[12] Along with a range of likely negative changes in further categories of natural asset, a truer measure of net saving in the UK for that year – which further deducts this damage – could be strongly negative.

This pessimistic conclusion is also reinforced by considering the relatively optimistic assumptions that underpin Figure 1: i.e. it assumes what matters is how assets are accumulated in the round. One issue is that the value or productivity of different assets may depend on one another. For example, a study (for the UK National Ecosystem Assessment) found that the proximity of some UK residential properties to green space and other natural amenities might account for more than one third of the asset value of these homes.[13] This strongly suggests that some proportion of the roughly £4 trillion value of residential property on the UK national balance sheet for produced assets is actually (capitalised) nature-based benefits from, for example, proximity to greenspace. This greenspace will also affect the productivity of human capital to the extent that it has a positive influence on physical or

[12] Hamilton *et al*. (2014) for the New Climate Economy project.
[13] See the recent study by Gibbons *et al*. (2014) for an indication of this.

mental health. There is growing evidence too of the empirical significance that air quality has on human capital (see also Section 3).

In addition to this influence on other assets, natural assets provide flows of benefits which could be at risk if these assets are in decline. Some indications of this can be gleaned from a risk register for natural assets; that is, a formal way of recording the state of natural assets by assessing whether the condition of (and trends in) these assets places benefits at risk.[14] From an economic growth perspective, further extensions to such a register might be contemplated to assess: (a) whether these benefits show up in GDP (or contribute more broadly to wellbeing); and, (b) the extent to which substitutes are unlikely to exist for (the goods or services give rise to) these benefits.

Both pieces of information are important. If natural assets are in decline as well as matter to the economy and cannot be substituted then these declining inputs again will lead to a drag on growth. The significance of this drag will depend on the empirical significance of the benefit provided by the resource. However, even if not large relative to the economy, there could be distributional impacts on particular communities where, for example, specific economic sectors are affected detrimentally by these limiting factors. Coastal fisheries provides an example of this.

Of course, technological change may help here.[15] This could take a variety of forms. It might enable production processes to make do with fewer and fewer inputs from particular natural assets in generating the same (or more) output. Or it could result in technologies which ease the burden on natural assets in other ways; perhaps by reducing by-products which degrade natural assets such as pollution or that enhance the effectiveness of policy actions to protect natural capital (e.g. by improving or reducing the costs of monitoring).

[14] Mace *et al*. (2015) set out a framework for such a risk register for UK along with a preliminary practical assessment. The latter indicates that the benefits from clean water from uplands are at relatively high risk as a result of the condition of these land resources. Diminishing these benefits presumably implies elevated water treatment costs or a decrease in the quality of water inputs to production. In other cases, such as woodlands, the risks to benefits are rated as relatively low. Indeed, at face value, this land cover has been increasing (see also, ONS, 2015). Yet the location (as well as quality) of much of this land use strongly suggests that benefits are lower than need be (see, for example, NCC 2015, for a case study of investing in UK woodlands which makes this clear in cost-benefit terms.

[15] Technological change is also important even where substitution between assets exists (Smulders and Withagen, 2013). If natural capital is declining but there are diminishing returns to accumulating replacement assets, then the growth drag may happen anyway. That is, the productivity of the next (marginal) investment will be less and less. Technological improvement is needed therefore to maintain the marginal productivity of these substitute assets.

Just as technological change has been crucial (perhaps the most crucial) driver of economic growth prospects more generally, so it may be similarly important for natural assets and circumventing the growth drag that too little natural capital might otherwise place on the economy. However, this possibility should also prompt some further considerations.

Technological improvements are likely to act on some natural assets but not necessarily all. For example, technical alternatives exist for taking physical exercise which do not involve the provision of greenspace. Whether these substitutes also provide benefits for mental health is less clear. A published review of technological substitutes for ecosystem services provides some interesting insights in this respect.[16] That assessment concludes that the claim of "non-substitutability" is too quickly reached for, but there are plenty of instances where the assertion is valid. This is particularly the case where natural assets provide critical (and widespread) supporting services rather than specific goods and services which are more direct inputs to economic production.

It is also clear, from this same review, that when these technological improvements may occur is not only uncertain but also unlikely, in many cases, to be immediate. That strongly suggests that incentives need to be in place for innovation to be of the right sort, in terms of relieving the pressure on natural capital. It might also suggest giving greater priority to investing in natural assets as part of the balance of assets within the economy provides some insurance against this uncertainty and mitigates against risks to growth in the interim. It is to this issue that this note now turns.

## 3. Economic growth benefits of investing in natural capital

Whether cast in terms of adjusted saving in relation to the whole economy or a more fine-grained assessment of a register of natural assets (and benefits) at risk, an interim conclusion for the UK is that economic prospects could be diminished as a result of declining natural capital. Yet, restoring these assets – as in the 25 Year Plan recommended by NCC (2015) – will amount to a serious programme of investment. Such a programme entails significant costs and necessitates priority setting for investment. Criteria in this respect might include the state of natural assets and the degree to which these assets are most at risk along with considering where the benefits of investment appear to be the highest (for example, relative to costs). The implications of this investment for economic growth prospects could be a logical supplement to this prioritisation process.

[16] See Fitter (2013) for this excellent discussion.

In what follows, therefore, some initial inferences are made for some of the illustrative (natural asset) investment cases discussed in NCC (2015). This includes: improving air quality; improving and expanding urban greenspace; woodland planting; upland (peatland) restoration; wetland creation; protecting and expanding intertidal habitats; and, improving fisheries management. For all of these cases, the focus of the following is on changes which are likely to manifest in "GDP".[17]

Some of the most important of pathways from investing in natural assets to economic growth might work through enhancing human capital.[18] In the case of *urban air quality*, this includes the well-established link between the smallest particulates (PM2.5) on mortality which in the UK is estimated to be in excess of 29,000 deaths per year. Some recent attention has focused on the implications of this (and related morbidity associated with exposure to air pollution) for productivity with findings, for example, that pollution-related illness is responsible for more absences from the workplace over recent years than industrial disputes. Data being prepared by the World Bank show that if not for mortality-related losses in productivity, from 1990 in the UK, GDP could have been more than 4% higher by 2010 (i.e. in excess of £60 billion higher in 2010 prices).[19]

Emerging evidence recently has pointed to further ways in which air quality could influence human capital.[20,21] As well as pollution-related absences from work, there could be an 'at work productivity' effect too. One study found that a small change in the exposure of US agricultural workers to ground-level ozone could lead to more than a 5 per cent change in (at work) productivity. The relative vulnerability of children to poor air quality is implicated in an additional pathway. For example, a recent study for Israel found that changes in PM2.5 and carbon monoxide were associated with lower school assessment grades for high-school age children. An earlier study of the exposure of US children to PM2.5 and its effect on maths

[17] It is also important to note, of course, that such investments will have important impacts beyond the measured economy which are also highly relevant to any assessment of worth (see, NCC, 2015).

[18] This then connects at least some natural assets to theories of economic growth based on the supply of high-skilled, well-trained workers that move an economy to its technological frontier and the positive spill-overs entailed in the more general sharing of knowledge embodied in the human capital in individuals.

[19] Esther Naikal, personal communication, May 2015.

[20] See, for example, Graff Zivin and Neidell (2013) for a review of this emerging literature which includes Lavy *et al*. (2014).

[21] This focus on human capital in discussions of the consequences of air pollution has perhaps been underplayed by environmental economists. This is in part a missed trick but it is also understandable. In particular, the concept of human capital in this context appears to lead to unpalatable implications with its exclusive focus, in practical terms, on productive value. This concern remains valid. Any renewed analytical emphasis on human must be complemented by an evaluation of the burden of pollution on people's wellbeing more generally.

and literacy results concluded along roughly similar lines. What is driving such findings appears to be less clear. The limited evidence to date suggests a combination of school absences and reduced productivity while learning at school as well as reduced performance during days of particularly poor air quality. The implications, however, could be far-reaching. The aforementioned evidence from Israel also finds a link to reduced probability of successful high school graduation.

This influence on human capital is not restricted to changes in air quality only. To the extent that the provision of more (and better quality) *urban greenspace* can be said to enhance physical and mental health then plausibly this could lead to greater labour productivity and permit acquired human capital to be more effectively used (by reducing absenteeism or improving productivity at work). Quite what the empirical significance of this is needs further substantiation. However, top-down estimates of the costs of poor mental health to the UK economy (and wellbeing more generally) are striking and provide a rough indication potentially what is at stake in its totality.[22]

The improvements in health that lead to this increase in human capital also have other benefits with implications. Among these are resource savings. An example of this is an estimate by Natural England that if every household in England were provided with equitable access to good quality greenspace, then savings of £2.1 billion could be achieved every year in averted health spending. For air quality, different effects on the economy are likely to depend on the policy action chosen to facilitate the investment. That is, some actions to improve air quality – e.g. tightening of technical standards – could accelerate the obsolescence of older vintages of produced assets and hasten the introduction of newer (and technologically superior) vintages.[23]

Synergies with produced assets might be one benefit of investments in protecting and expanding *intertidal habitats*. This might happen because of the flood protection benefits that this investment provides for physical infrastructure or agricultural land.[24] In this instance, the natural capital investment is a substitute for a produced asset (e.g. a seawall) that provides this same benefit. However, the former may be more effective. The investment could provide

[22] For example, OECD (2014) estimates that the losses to the UK as a result of mental health amount to about 4.5% of GDP (or £70 billion per year, arising as a result of impacts on productivity, health treatment costs and other expenditures).

[23] See Bowen (2015) for a discussion of this point.

[24] For example, one study of flood protection measures in England found that projects could yield benefits that were 8 times in excess of costs. Chief amongst these benefits is the protection of produced assets from flood risks and so show up in GDP (or higher values in the UK's national balance sheet for produced assets).

more flood protection than existing produced assets and, in doing so, avoid the need for more costly upgrade of existing defences and subsequent maintenance requirements. Similar observations broadly apply to investment in *improving wetlands* with regards to the provision of flood protection benefits as well as water quality improvement. Indeed, there may be a premium to coordinating these investments through management of a catchment rather than as incremental and isolated investments. If so, then this combinatorial approach seems analogous to an investment in a network or infrastructure of assets.

In the case of investing in *better management of commercial fisheries*, opportunities for improving growth prospects arise as a result of correcting persistent over-fishing. Paradoxically, this unfavourable current situation means that there are likely to be substantial benefits from better management of that stock with some estimated ratios of benefits to costs indicating the scope for improving the productivity of the underlying asset (and so enabling a move to higher level of output). An extensive study of UK fisheries[25] identifies a number of instances in which current returns were low or dissipated altogether; either as a result of excessive fishing effort, a dwindling stock or some combination of the two.[26] How significant this is for the whole economy is arguable. Nonetheless, such relative improvements are likely to be have important distributional effects.

Such an investment is not without sacrifice of course. Reflections on whether this sacrifice is tolerable must consider that this current situation may not be sustainable. If current stocks are too low, the chance of collapse is all the higher as critical thresholds are approached. Put another way, one element of the benefit of this investment is that *expected* growth (and *expected* asset values) is higher because natural capital is being managed more sustainably (and so less likely to collapse in the future).[27]
The 'Grand Banks' fishery in Newfoundland, Canada is the most rehearsed cautionary tale about the (possibly irreversible) misuse of this specific natural asset.[28] The closure of the fishery led to substantial economic losses in that sector and beyond (such as the costs of increased social security provision and so on). Although it has many features of a special

[25] Cunningham *et al*. (2010).
[26] For example, the finding is that catches from current stocks of species with high natural productivity such as herring may be sustainable, the present level of fishing effort means that little (if any) return is provided by the fishery. For other species, particularly white fish such as cod and haddock, better management is also likely to require currently depleted stocks to be re-established.
[27] There is a more general point here too about setting target for natural capital investment. Just as some minimum supply of any asset (e.g. physical infrastructure) presumably would not be viewed as a sensible target for public policy, setting targets to manage natural assets at analogously minimum levels would not be sensible either. In order to realise this (expected) benefit from greater resilience, operating at some point further away from potential thresholds is required.
[28] See, for example, NCC (2015).

case, the issues it illustrates are far from unique. That is, options to realise greater benefits are jeopardised and potentially closed off permanently by persisting with institutions that manage natural capital with the short-term only in mind.

## 4. Concluding remarks

Claims made about the way in which natural capital influences economic growth will depend not only on what natural assets are under discussion but also what judgements are being made about those assets in relation to the economic process. For example, if these assets are judged to be substitutable then growth concerns shift to considering whether a country is accumulating enough assets on balance. Yet even on a basic indicator – i.e. depletion adjusted net saving – prospects look far from assured based on the example for the UK.

If it is reckoned that substitutability is far less straightforward then this assessment becomes more pessimistic still. That is, it becomes more likely that unsustainable use of natural capital (which cannot easily be replaced) places a drag on economic growth. Technological change may well be important (just as it is crucial elsewhere in the economy) in easing these constraints and pressures. Whether this will happen sufficiently quickly (e.g. within a generation) is contingent. A programme to invest in natural capital is therefore likely to have worthwhile outcomes for economic growth whether this is based on improving productivity by boosting stocks of natural assets which are currently too low or enhancing other important asset categories such as human capital.

The empirical significance of any growth boost and, additionally, whether it is greater (or less) than the growth benefits of alternative (non-natural capital) investments remain important questions. This is something to consider not only in relation to the whole economy but also with regards to distributional considerations. Also important is evidence about the character of this growth; that is, does it comprise benefits which are reflected in growth of the measured economy or not? Yet there is no reason to think that these impacts are necessarily trivial given the importance of natural capital to significant economic sectors and activity (e.g. tourism and recreation) as well as the role of some pervasive natural assets (e.g. greenspace and urban air quality) in enhancing human capital.

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