WATER THOUGHTS 3

Water as Wealth; Seen within a Portfolio of Assets

There are three broad categories of wealth: produced capital; human capital; and natural capital. Since 1992 humanity has achieved impressive advances in the value of produced capital, a worthwhile advance in human capital, but depleted the stock of natural capital at an alarming rate. In order to value these three categories of capital, prices are needed. One reason natural capital has been depreciated to this extent is that in respect of key components of the measure, such as water and fossil fuels, according to the recently published Dasgupta Review, prices for much of natural capital are not only non-existent but treated as negative by many countries. In many cases this is as a result of the absence of traded markets, which incentivises the exploitation and degradation of elements of natural capital. In order to stabilise and reverse this decline in natural capital a dramatic increase in the rate of innovation in the use of natural capital is vital. The establishment of markets in elements of natural capital such as water would be an important step towards incentivising innovative solutions in their use and reverse the decline. Innovation does not involve mere growth, incremental increases, but can give rise to a quantum leap in performance, the efficiency with which water is used in production.

Thunder on the mountain, and there's fires on the moon
A ruckus in the alley and the sun will be here soon
Today's the day, where I'm gonna grab my trombone and blow
Well, there's hot stuff here and it's everywhere I go

Thunder on the mountain heavy as can be
Mean old twister bearing down on me
All the ladies in Washington scrambling to get out of town
Looks like something bad is going to happen, better roll your airplane down

Gonna make a lot of money, gonna go up North
I'll plant and I'll harvest what the earth brings forth

From Bob Dylan (2006) *Thunder on the Mountain*

Complementarity between the worlds of Finance and Sustainability

If water is not priced then it tends to be treated as of no consequence and is liable to be squandered or despoiled. There is more than one framework within which this point can be developed and explored; in this piece we explore the point in the context of the perspectives articulated in the Dasgupta Review, the UK government sponsored review led by Prof Partha Dasgupta, Professor of Economics at Cambridge, "The Economics of Biodiversity", 2 February 2021. Henceforth simply referred to as the "Review".

It is not often that a government report can be called inspirational, but this one arguably is. Moreover in the approach taken, it builds a bridge between the disparate worlds of finance and sustainability and demonstrates the complementarity between the two. The opening statement of the report makes this clear. "We are all asset managers", pg. 11. It goes on to expand on this point as follows, "…the best each of us is able to achieve with our portfolios may result in a massive collective failure to manage the global portfolio of all our assets…in recent decades humanity has been degrading our most precious asset, the natural environment, at rates far greater than ever before".

At Odds with a Short-term Focus on Growth

This focus on wealth immediately introduces a framework for the preservation of biodiversity and sustainability that is in some respects at odds with a short-term focus on growth. Instead, what may be more germane to the discussion of sustainability is the medical credo to "first do no harm". It is all too easy to achieve growth by running down existing assets, both at an individual and societal level. As individuals we can work more hours by neglecting exercise and recreation, and perhaps achieve a promotion or a pay rise, but at the expense of our human capital. Moreover, I will argue below and explore the point that for innovative companies, such as those listed on Nasdaq, growth is not really the objective either, but seismic leaps, fuelled by innovation are what companies strive for. It is mature companies that are content to grow revenues by 2-3% per annum.

An important issue highlighted in the Review is that the performance of GDP, *Gross* Domestic Product, may be the wrong metric for policy makers to target. The concept of GDP, the system of national

accounts was initially constructed to enable policy makers to track production throughout the US economy when it was on a wartime footing. It is easily possible to achieve a burst of growth but at the expense of existing assets so that if measured correctly the net result would be negative once account is taken of depreciation. Stated more simply, GDP is not a stock of wealth concept, it is a flow of production concept; maximising GDP growth does not necessarily even lead to an increase in the stock of wealth, which may decline. One can make a case that in moderately affluent societies such as the US or the UK, growth as such is no longer the issue. For the reasonably prosperous, the achievement of marginal gains is not of pressing concern. There remains of course a societal imperative to raise the living standards of the least well off, and to increase the life chances of their children. But this worthy agenda is distinctly different to one aimed at achieving growth at the level of the macro economy.

So how does Dasgupta's focus on wealth fit into a sense of our connection with nature, and in particular **water** resources? The review anchors the discussion in the sustainable development goals of the United Nations:

Figure 1 17 Sustainable Development Goals Adopted by All United Nations Member States in 2015

Source: United Nations (2015).

Figure 1

Two of these goals specifically relate to **water** and **water quality**: clean water and sanitation, and Life below Water. But it is hard to see how a few of the others could be achieved without an adequate supply of good quality water, especially zero hunger; sustainable cities and communities; and life on land.

The Biosphere is the Largest Ecosystem of which we are an Element – It is Our Home

Two of the key concepts referred to in the report are the biosphere and biodiversity. The review notes that we inhabit and form part of the biosphere. "The biosphere, which is the part of Earth occupied by living organisms, is a regenerative entity…living systems in turn make use of the non-living, or abiotic, material in the biosphere and transform them; **water**, carbon, and nitrogen cycles are expressions of that. Because the ability to regenerate is a characteristic of living systems, regeneration of the biosphere is key to the sustainability of the human enterprise". In other words, humanity depends on services from the rest of the biosphere for our very survival, of course we obtain both medicines and food from the rest of the biosphere. Within the biosphere, various ecosystems exist. According to the Review, "each of us is an element in many ecosystems. We each contain microbial ecosystems. The biosphere is the largest ecosystem of which we are an element – it is our home." The microbial ecosystems are those bacteria which live on our skin and exist within our gut in a symbiotic relationship; they boost our natural immunity. The biosphere describes the interaction of living organisms at the macro level, on planet earth. Diversity is the key to the sustainability of life forms and hence their resilience. Over-use of antibiotics can lessen our natural immunity to infection by reducing the diversity of our gut bacteria. As the biosphere loses diversity it loses resilience to shocks; unexpected events which cause departures from the norm. As we shall see, floods are often a feature of this phenomenon. The review defines biodiversity as "(b)iological diversity, or biodiversity for short, means the diversity of life in all its forms. It is not uncommon though to regard biodiversity to be the number of species of organisms that inhabit Earth. Today there are 8-20 million species of organisms, maybe more, with cells containing a distinct nucleus that houses genetic material in the form of chromosomes (such organisms are called eukaryotes)."

How does all this relate to the points we were earlier making about the economy, and **water** as wealth? Here, a further diagram from the Review serves to establish the connection:

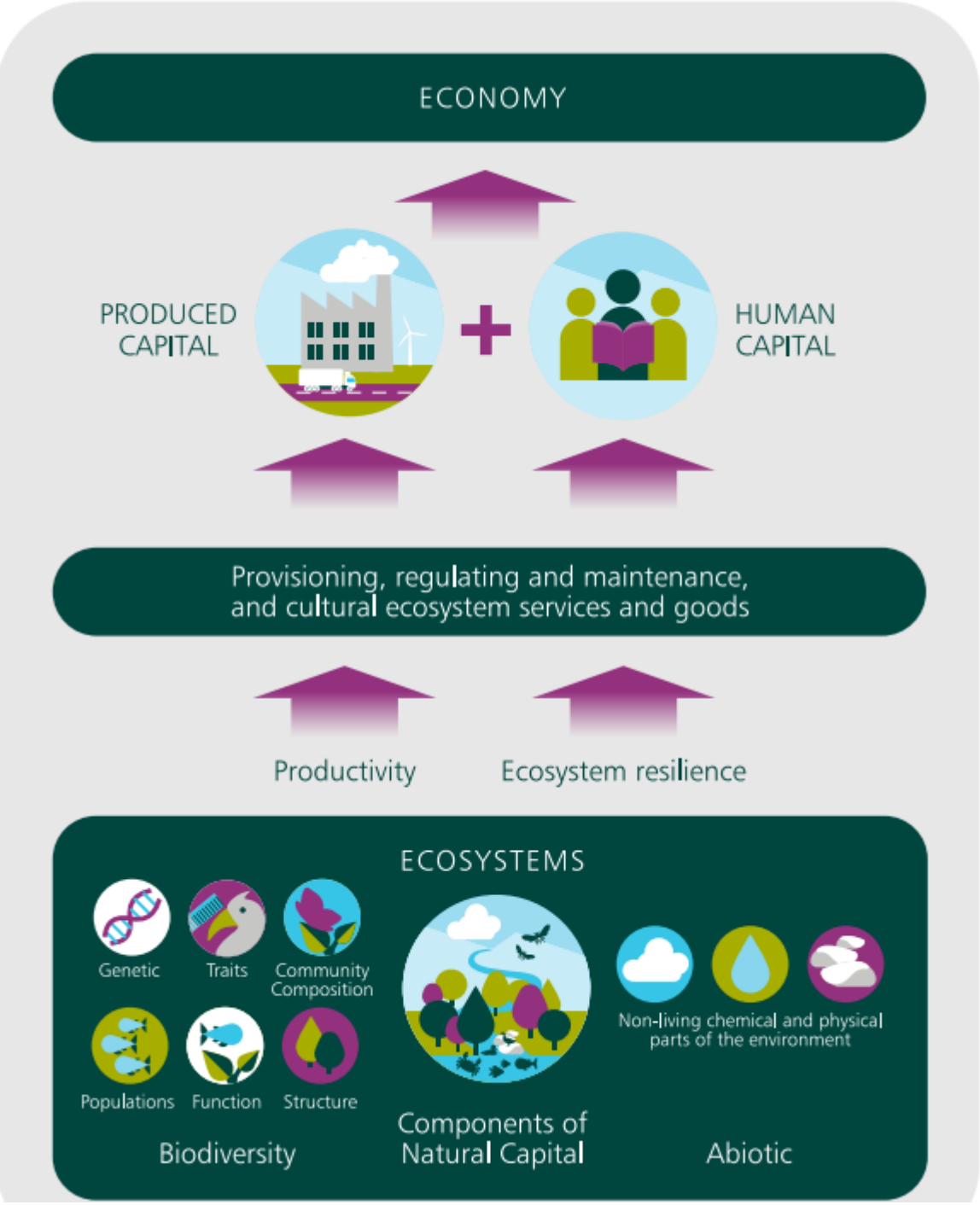


Figure 2: Biodiversity all the way through to the Functioning of the Economy

Within the diagram, it is important to note that **water** is a "provisioning service". On pg.16 the review explains that "Nature's goods and services are the foundations of our economies. They include the provisioning services that supply the goods we harvest and extract (food, **water**, fibres, timber, and medicines) and cultural services, such as the gardens, parks and coastlines we visit for pleasure, even emotional sustenance and recuperation." Elaborating on this point, the shortage of a provisioning service, of which **water** is a key element, can exert a binding constraint on production, such as the

supply of electricity, and goods and services that depend for their production on the supply of electricity, as noted in our previous essay.

Monoculture can create the Conditions by which Floods Occur.

Certain aspects of the modern economy, such as modern agricultural monoculture, are highly productive but lessen biodiversity. Indeed, in a particularly trenchant piece on this as it relates to Britain, the author and wildlife enthusiast George Monbiot argues that British agricultural practices are far from productive, and may be destructive of monetary value (Monbiot,2013). Much of the natural world in the UK, rural Britain, is not as nature intended it, but consists of cultivated pastures given over to sheep. Seen through the window of a speeding train it all appears tranquil and lovely to the eye, but all those pleasant green pastures are not as nature intended the vegetation to be. Monbiot contends that "deep vegetation on the hills absorbs rain when it falls and releases it gradually, delivering a steady supply of **water** to the lowlands. When grazing prevents trees and shrubs from growing and when the small sharp hooves of sheep compact the soil, rain flashes off the hills, causing floods downstream. When the floods abate, **water** levels fall rapidly. Upland grazing, in other words, contributes to a cycle of flood and drought. This restricts the productivity of more fertile lands downstream, both drowning them and depriving them of irrigation **water**…Sheep have reduced most of our uplands to bowling greens with contours."

From Monbiot's account, floods which occur all too often in regions where they did not occur previously are not a symbol of the overabundance of **water**, but a sign of something gone wrong, especially of environmental degradation. Floods are sometimes the canary in the coal mine.

Farmers in the UK would strongly dispute Monbiot's claims regarding the environmental impact of sheep farming. They would argue that sheep farming in the UK is "twice as efficient" as in other comparable countries, and that sheep are now being partly fed on algae in order to avoid the use of agricultural land that could have been given over to the cultivation of fruit and vegetables for human consumption, instead being used to provide pasture for sheep to graze.

This controversy has parallels with the discussion surrounding the reorganisation of supply chains currently taking place. For some years, supply chains were characterised by ever greater specialisation, along the lines of comparative advantage, with activities assigned to locations at which production could take place at lowest opportunity cost. Then, along came the covid-19 pandemic, and the disruptions to supply chains that resulted, and firms hosting supply chains realised that supply chains organised along the lines of maximum efficiency are not necessarily resilient to shocks; that in fact a trade-off may exist between resilience and efficiency. If an area of agricultural land is cleared to facilitate mono-culture and maximum efficiency, so as to maximise the value of output yields, a single adverse weather event such as an extreme frost could decimate the whole crop, which would not occur if the original diverse vegetation had been preserved.

From **Figure 2** above, there are three broad categories of wealth that are germane to the argument. Produced Capital, Human Capital, and Natural Capital.

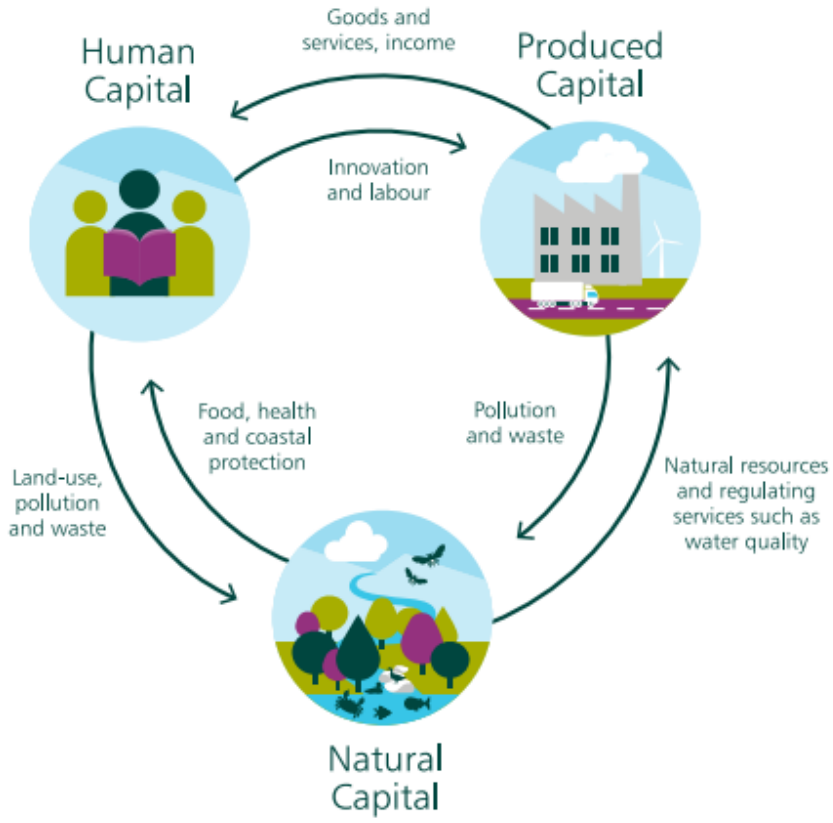
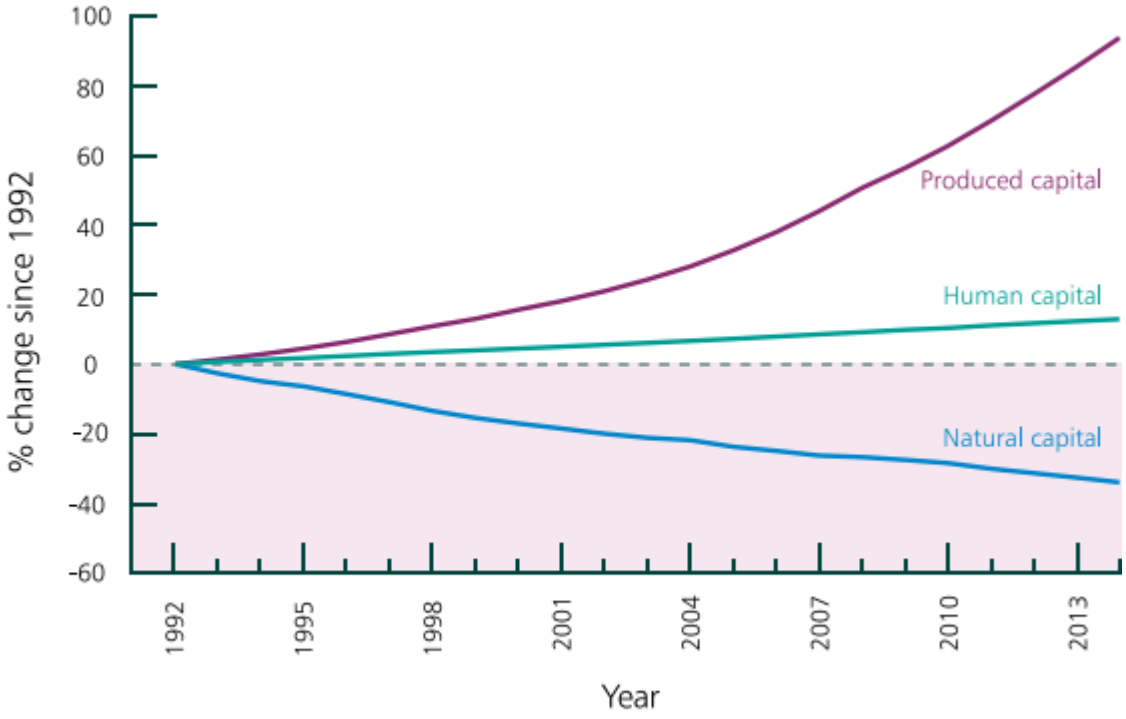


Figure 3: How the Capitals are Intertwined

The factors that enhance human capital are human health (partly a function of a better environment) as well as of course healthcare institutions, better housing, and acquired education and knowledge. We can see from the diagram the role that **water** plays as a provisioning service, akin to a factor of production interacting with produced capital in order to contribute to the supply of goods, services and income. Increasingly, in many countries and in particular sectors such as energy supply, lack of **water** consequent of drought conditions exerts a binding constraint on economic production and monetary output. Within this framework, estimates have been made of the evolution of the monetary values of each of these:



Source: Managi and Kumar (2018).

Figure 4: Global Wealth Per Capita, 1992 to 2014

From the above it can be seen there have been astonishing increases in the value of produced capital since the date of the estimates shown above 1992 through to 2014, these are even more impressive if dated back to the start of the industrial revolution in 1820 but consistent time series of all three measures of capital dated back till then are not available. In comparison, there has been a lesser but still worthwhile increase in the stock of human capital since 1992, but at the expense of running down natural capital at a rate that is uncontestably alarming. To put this in context, 1992 roughly coincides with the start of the second, knowledge-driven phase of globalisation identified by scholars such as Baldwin (2016), or digital globalisation.

Now, it won't have escaped the notice of the astute reader that in order to perform the underlying calculations, to attach values to each of the three capitals, we need to determine prices for them. Moreover there is often a distinction between market prices, and true prices which reflect the value of each component of each of the three capitals to society.

The true price of each element of each of the three capitals is not necessarily the same as its market price, but "the contribution an additional unit of it would make to societal well-being (or more narrowly, the common good"). These true prices are referred to in the Review as accounting prices, but I prefer the term widely used in Welfare Economics, shadow prices.

Market Prices Rarely Lead Societies Wildly Awry

While market prices may not be the true prices in an academic sense, market prices tend not to lead societies wildly awry either. This is why economies that are coördinated via a myriad market prices and a multitude of transactions between individuals and firms are generally more prosperous with a

far greater sense of wellbeing than is experienced in command economies managed by diktat from the top down. The greater consequence can be seen from the absence of particular markets, or missing markets, which results in no price at all, especially for provisioning services, and dire outcomes all round.

A key passage in the Review is where it notes that, "as there is enormous waste in our use of provisioning services (global food waste alone, from source to final consumption, is an astonishing 30% or thereabouts), there is scope for efficiency gains. There is also waste attributable to the wide range of subsidies we pay ourselves for the use of Nature's services. *Many of the biosphere's goods and services (e.g.* ***water****, fossil fuels) thus come with a negative price tagged to them.* Globally, Nature's subsidies amount to an annual US$4-6 trillion, or approximately 5-7% of global GDP". Pg. 32, italics added. The Economist magazine, October 9th, 2021, notes that the IMF estimates that global fossil fuel subsidies amount to 0.4% of GDP. Far from phasing out the use of fossil fuels in production, many governments are actively subsidising their use, which leads to an effective negative price for the use of fossil fuels. As we note below, this has negative knock-on effects on **water** use, since energy is used in the pumping of water.

Curiously, almost everybody can see the importance of creating carbon markets and establishing CO_2 prices, as a disincentive to firms treating the atmosphere as a dumping ground for their CO_2 emissions. But many find it difficult to appreciate that establishing a positive price for **water** via the creation of water markets incentivises heavy users of water to economise on its use and preserve its quality for other users, which is especially crucial since **water** sometimes has dual or multiple uses. **Water** used for recreation does not preclude its subsequent use in agriculture. Sans **water** markets, the price applied to **water** is not zero, but according to Dasgupta, some users treat water as if it has a negative value attached to it, which encourages this overexploitation and degradation of this precious resource.

Heroic Efforts to Create Water Price Signals

Infant markets for **water**, and market prices for water they produce, may be too low relative to the social value of water, but at least a positive price for **water** is a step in the right direction to preclude the unconscionable waste that otherwise arises when there is no value attached to this vital element of natural capital. There is a case to be made that the various pioneering efforts to create tradeable **water** markets, enabling water to be diverted to its most efficient uses, and efforts to create a widely available price benchmarks as an information input to guide the decisions of market participants, can be construed as heroic.

A Model, A Body of Water

The model within which we can explore the drawing down and replenishment of natural capital fortunately works with the metaphor of a body of **water**. Imagine a fresh **water** lake stocked with fish. If the initial stock of fish is low relative to the carrying capacity of the lake (the nutrients it is able to supply via for example insects breeding on the surface of the lake), the fish multiply and increase in number. Once there are too many fish to be fed by the supply of nutrition the lake provides, the numbers of fish decline until equilibrium is reached. Then introduce fishing into the picture. A certain amount of fishing is sustainable because sufficient fish remain after a few are caught that if left

untroubled they are able to regenerate to the previous maximum number the lake is able to sustain and nurture. But if fishing occurs at such a rate that the stock is depleted at a rate in excess of the ability of the fish to regenerate, eventually the lake will be barren of any fish. Equally, if a nearby business treats the lake as a free resource, and dumps industrial run-off in the **water**, the carrying capacity of the lake in terms of healthy fish it is able to sustain that are safe for human consumption is likely to be markedly lower.

This idea is expressed in the Review both in diagrammatic form and via an equation. Here we show the diagram first, but it is the equation on which we wish to focus our attention:

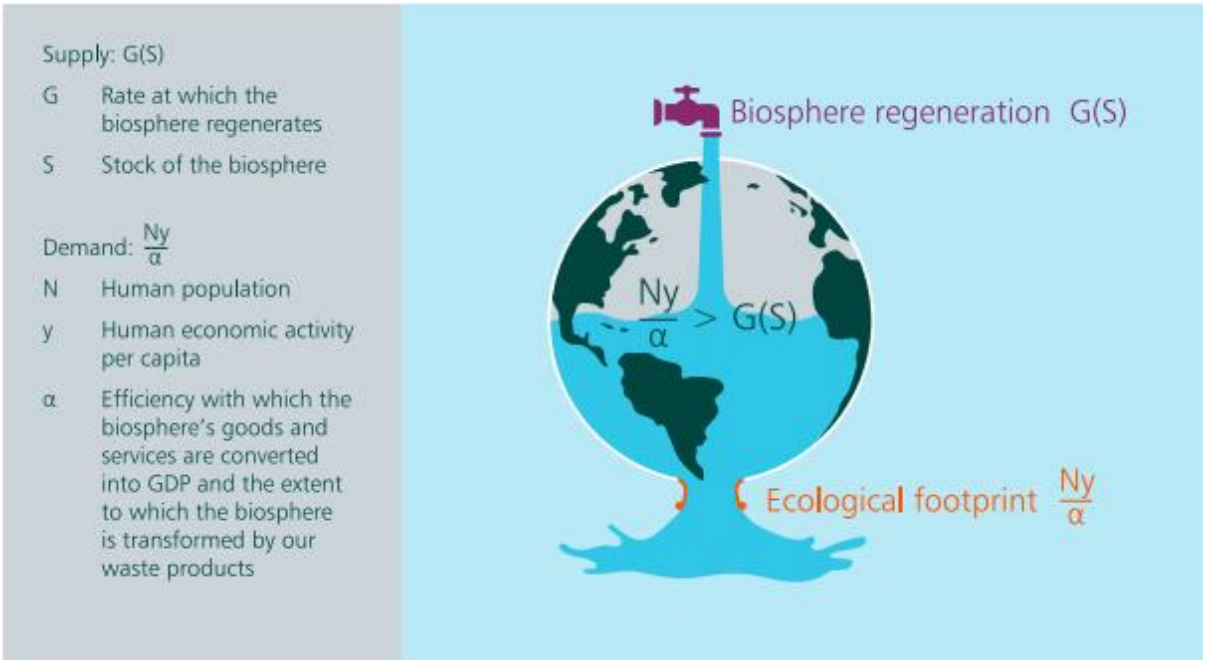


Figure 5: Regenerating at a Slower Rate than it is Depleted

Here, instead of focusing merely on fish, we now turn our attention to the whole biosphere, and the rate at which it regenerates, illustrated by **water** running from the tap at the top of the world. And the ecological footprint is represented by **water** draining out of the bottom of the world, determined by the demand we place upon the ecological services.

The fact that we have been drawing down natural capital at an accelerating rate, as depicted on **Figure 4** is down to the workings of the following impact inequality, expression (1):

$I = Ny/\alpha > G(S)$ …(1)

Where I is the impact the activities of humanity is having on natural capital, and this is equal to the size of the global population, N multiplied by global GDP per capita, y, all divided by α, which is the efficiency with which the provisioning services of nature are used in the production of Ny. And, from Figure 4 above, this I has clearly been exceeding G (the regenerative rate of ecological services), which is a function of S, the stock of ecological services.

Now, in the short to medium run there is little any single policy maker can do to affect the path of Ny over time. Growth in the mature economies may slow down, but this is likely to be matched by faster growth in leading economies in the developing world. Population projections do not differ greatly from one another – the Review notes that the optimistic (lower population) scenario only diverges to a material extent from the mainstream widely accepted scenario from 2070 onwards. Further substantial population growth is already baked in it seems. Concomitantly, it appears imperative that we arrest the ongoing decline in natural capital, and quickly!

Old Style Growth may be Harmful

To return to the argument above, growth in GDP can be wrongly interpreted as a welcome and positive occurrence, when if assets are being depreciated at a faster rate than GDP is increasing, the net effect is to go backwards, not forwards as the losses exceed the gains. Old-style growth is in any case measured using the wrong metric, GDP. As the Dasgupta Review notes, by definition this is a Gross measurement, it does not account for any depreciation of assets, including natural capital, achieved in the process of generating that growth.

To find a glimmer of promise in this seemingly inexorable conundrum, we turn instead to the innovation term, the α term in the expression (1) above. A few illustrative numbers highlight it's significance. The Review assumes that global GDP growth (the numerator term in the expression above, Ny, continues to expand at its post 1970 rate of 3.4% per annum, measured in real terms. World population growth, about which little can be done to alter its course before 2050 or so, is rising at a rate of 1.1% per annum. There is a secular stagnation hypothesis, which is that growth in the future will be markedly slower than 3.4% per annum. The secular stagnation hypothesis does seem to have some substance to it, so growth in the future may indeed be slower than 3.4% per annum, but for the purposes of this essay I will work with the assumptions of the Review. For growth to continue to match 3.4% per annum, China would have to continue to grow at its breath-taking pace since 1990, which seem to be unlikely as China becomes richer overall.

The value of the stock of natural capital is estimated to have declined at a rate of 1.2% per annum over the same period. The ratio of the impact on the stock of natural capital I, the rate at which it is being drawn down, relative to G, the rate at which natural capital can regenerate, is estimated to have risen to 1.7. The shocking part in this is the rate at which efficiency in the depletion of natural capital would have to improve merely to bring I and G back into alignment over a period of ten years. The historical rate of increase in the innovation, or efficiency parameter has been 3.5% per annum. To reduce the impact to regeneration ratio to 1, this would have to surge to a rate of 10% and be sustained at that rate over ten years. Even if Ny was somehow held constant, via the imposition of lockdown type restrictions instead of being allowed to rise, the calculations in the Review show that α would then have to rise at a rate of 5.5% per annum up until 2030 to bring I and G back into balance. From every which way this is viewed, it seems that an improvement in efficiency (less waste) or innovation in the use of natural capital, including **water**, is an inescapable feature of any workable solution that does not build up to an emerging natural catastrophe. Here we are developing an argument via the numerical solutions to an inequality. Bill Gates argues along similar lines in highlighting innovation and makes the argument more colourfully and poetically below.

Eschewing old-style growth is not the same as Forgoing Increased Prosperity

Our contention in this paper is that shifting the focus away from short-run GDP growth to one of the management of the overall stock of wealth including of natural resources will not give rise to a society in which advances in prosperity are in the past. Foregoing growth in the sense of relentless increases in gross output is not the same as forgoing increasing prosperity. Of course, advances in prosperity when measured ex-post will be measurable as growth, but via a different dynamic than that which currently drives growth. Ultimately though it has to be recognised that there is an eventual limit, as the Review points out, to the extent to which innovation can enable growth to continue without depleting the stock of natural capital.

Take computing for example: While Moore's Law (that computing power doubles every 18 months) has dictated that the power of computers has advanced at an impressive rate, an even more exciting prospect lies just over the horizon. This is the promise of quantum computing. Quantum computers will, it is claimed, be a factor of 10^{14} more powerful than extant computers of today. Company innovation works like that in general. Innovative companies are on the lookout for products and processes that will transform their business fortunes by a quantum leap. Quantum leaps do not necessarily place any greater demand on the ecology than old products and processes did; indeed the impact may be less rather than greater. It was Arthur C. Clarke who once observed that in the future advanced technology will be indistinguishable from magic.

Innovation – Advanced Technology as Indistinguishable from Magic

Of substantial interest therefore in equation (1) is the efficiency variable, α. Because, depending on the rate at which we are able to innovate, seismic shifts are possible.

This perspective also illustrates that Bill Gates is on profoundly the right track when in his latest book he places such an emphasis on Innovation as a solution to the Climate Crisis. Extracts from an interview he conducted with the Harvard Business Review is as follows:

HBR: You write that even if we can cut carbon emissions in half, that would only postpone—not prevent—a climate catastrophe. Is there any precedent for a transition of this magnitude?

Gates: "This scale of change hasn't happened before. It will need to be the most amazing thing humankind has ever done. Making a vaccine for the coronavirus went quickly, but that was far easier… For climate, it's important that we not spend money on just reducing, say, electricity use by 15%. We need to invest in the innovations that will really make a difference…if you own farmland in Canada, you're actually going to get more crops because it will be warmer. But if you own farmland in Texas or Mexico, things will be bad. Crops like corn simply aren't going to grow there anymore. And for subsistence farmers near the equator—in parts of Africa, for example—it will be disastrous. They won't have enough food to survive… With the pandemic, it was uncertain which year it would come. I could have gone my whole life without seeing one. With climate change we can guarantee the ill effects. There are still questions: For example, will it be four degrees hotter or five? But disaster is guaranteed unless we reduce emissions very, very dramatically." The whole interview can be heard here, as an HBR IdeaCast/episode 780.

Within the voluminous literature on innovation, there have been scholars that have addressed the topic of innovation in relation to **water** specifically. Bouquet, Barsoux and Wade (2018), commence

their piece with the example of a researcher who spotted that groundwater levels in the Hyderbad area in India were “falling precipitously”. Upon investigation he discovered that this was not due to a change in rainfall patterns, but because farmers in the region had switched from cultivating millet, generally consumed by poorer households, to grow the far more prestigious rice crops, which requires sixty times more water to grow than millet. Subsidised electricity effectively rendered it incredibly cheap to pump water to irrigate their fields. Effectively, a negative price was being applied to water. The researcher Narayana Peesapaty first attempted to convince government of the folly of the existing policy regime, and the harmful outcomes it was producing, but achieved no traction going down this route. Instead, he hit on the idea of promoting alternative uses of millet, including edible cutlery made of millet, to render it attractive for farmers to grow millet once more. After a slow start, his business idea was a crowdsource funding success, exceeding the initial target of funds raised twelvefold. In future issues of **Water Thoughts** I hope to return to the topic of innovation as it pertains to water.

If precious water resources are not to be mindlessly squandered in the future, but preserved and nourished, clearly some sort of price vector to signal to users the value of water is required. Resources bereft of price signals tend to be treated by many users as of little to no value, and treated with disdain. In this respect, to establish a clear benchmark water price via traded water futures, which draw on the spot prices of water which is a compilation of trades from a number of disaggregated and disparate markets, is a vital contribution to this endeavour.

Is Pricing Water Fundamentally Unfair?

I commenced this piece by noting that price signals in relation to the use of water are necessary to prevent its despoilation and waste. But what of household users of water, many of whom are poor, how would water charges affect them? There is the quintessential poor, African woman, who has to undertake a hazardous journey occupying hours each day to obtain **water** to satisfy the needs of her household. What if a charge were to be levied for the water she consumes? Viewed from the standpoint of an economist, the water carried by the poor African woman is obtained at a very high cost, because of the opportunity cost or time cost associated each day with the struggle to obtain this precious resource. Moreover, the water may be dirty and unsuited to safe human consumption. If government were to supply this water instead, the quality thereof would be improved, and it would likely be both sanitary and quite possibly cheaper. Not having her time taken up by the daily search to procure water would free her to participate in at least informal sector economic activities, craftwork perhaps. Bangladesh provides a salutary lesson. Bangladesh has become a leading exporter of clothing and textiles, and since women are principally employed in the sector, although the incomes are very low, they have at least obtained a modicum of independence, via the cash earnings they are able to generate. In the next article in this series we intend to examine the various ways in which water use is charged, from fixed charges over a period of time, through to per unit charges to use, and the ethical and welfare economics of the myriad different ways of establishing a price for water.

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8th November 2021, updated 15th November 2021

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