Account for depreciation of natural capital

Economic indicators that do not include depletion and degradation of natural resources and ecosystems are misleading, warns Edward Barbier

Final Revision

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October 17, 2014

For the past year academics and policy makers have been discussing Thomas Piketty's economics bestseller, *Capital in the Twenty-First Century*. It documents the considerable rise over the past 40 years in national wealth relative to national income in the eight richest economies – the United States, Japan, Germany, France, the United Kingdom, Italy, Canada and Australia. For each of these countries, the wealth-income ratio has increased from 200-300% in 1970 to 400-600% in 2010.

Piketty relies on standard income conventions as proscribed in the U.N. national accounts for each of the developed countries. Although Piketty includes natural resources such as fossil fuels, minerals and forests in his estimate of a country's capital, his measures of national income and savings adjust only for depreciation of 'fixed capital' -- buildings, equipment, and so on.

Clearly, we must also account for *natural capital depreciation*, which is the value of net losses to natural resources, such as minerals, fossil fuels, forests and similar sources of material and energy inputs into our economy. If we use up more energy, mineral and forest resources to produce economic output today, then we have less natural capital for production tomorrow. Similarly, we are also squandering much valuable *ecological capital* – ecosystems, which through their natural functioning and habitats provide important goods and services to the economy, such as recreation, flood protection, nutrient uptake, erosion control, water purification and carbon sequestration. By converting and degrading ecosystems today, we are also depreciating this important ecological capital endowment. Finally, economies and people are better off as a result of improvements to *human capital*, such as a healthy, better educated and more skilled workforce. Thus, expenditures in the economy that lead to such improvements are contributing to net increases in human capital.

Here I show how economic indicators change especially when the depletion and degradation of natural resources and ecosystems are accounted for. Depreciation of natural capital is particularly high in developing economies, which are often rich in resources and ecosystems. We must retool our measures of income and wealth accordingly.

CROSSHEAD

For most countries since 1970, The World Development Indicators provide estimates of the adjustments to national income, income growth and savings that arise from net forest, energy and mineral depletion. This rate of natural capital depreciation as a percentage of adjusted net national income over the past four decades, for the same eight rich countries that Piketty analyzed, for developing economies and the world, is telling (Figure 1).

Two further global trends are also noticeable. First, the decline in natural capital has been five times greater on average in developing economies compared to the rich countries. Second, although natural capital depreciation in all countries fell to its lowest levels in the 1990s**,** as the world economy became apparently less dependent on resource exploitation, since then it has risen significantly again. There was a dip during the Great Recession of 2008-2009, but as the world economy has recovered and revived resource use, so has the rate of natural capital depreciation.

Another important form of natural capital – ecological capital – is also excluded from our approach to accounting for national income and savings. Because ecological capital is unique, poorly understood, difficult to measure, and tends to be undervalued, it has clearly been endangered by current patterns of economic development. Over the past 50 years, ecosystems have been modified more rapidly and extensively than in any comparable period in human history, largely to meet rapidly growing demands for food, fresh water, timber, fiber and fuel. According to the Millennium Ecosystem Assessment, approximately 60% of the major global ecosystem services have been degraded or used unsustainably, including freshwater, capture fisheries, air and water purification, and the regulation of regional and local climate, natural hazards, and pests.

What is urgently required is better measurement of the contribution of ecological capital to current and future economic well-being. The UN and World Bank has begun pilot studies to construct adjustments to income and wealth that include changes in ecological capital as well as in fixed, human and natural capital. The net domestic product (NDP) of an economy can and should be adjusted for these various changes in human, natural and ecological capital (Figure 2).

CROSSHEAD: Mangroves example

Consider the example of mangroves in Thailand over 1970 to 2009 (Barbier 2013). Thailand is estimated to have lost around a third of its mangroves since the 1960s, mainly to shrimp farming expansion and other coastal development. Yet mangroves provide four essential ecosystem benefits – collected wood and non-wood products (e.g. shellfish, plants, honey, medicines, etc.)**,** nursery and breeding grounds for off-shore fisheries**,** storm protection, and carbon sequestration. I use estimates of these benefits to determine the annual net gain or loss in mangrove value that results from conversion to other land uses (Table 1). This net mangrove value has two components. First, the remaining mangroves generate additional benefits each year that do not

appear in the national accounts, such as net subsistence for local coastal communities and economy-wide carbon sequestration benefits. But from these values must be subtracted the net loss in land value that arises from converting mangroves each year to some other economic activity, such as shrimp farming.

Although average annual mangrove loss in Thailand has fallen steadily in every decade since the 1970s, cumulative deforestation over 40 years has been considerable. This has resulted in significant long-run economic impacts (Table 1). First, during the 1970s and 1980s when mangrove deforestation was rapid, Thailand was losing -$1.69 and -$0.76 in mangrove net values per person per year. Second, by 2009, around a third of the mangrove area was deforested and Thailand's population had grown rapidly. As a result, the total value from the subsistence and carbon benefits of the remaining mangroves has halved, from $0.57 to $0.28 per person per year. This means that, even though mangrove loss slowed in the 1990s and 2000s, the net values of mangroves were very modest, only $0.11 and $0.25 respectively. Third, the 'price' of cumulative mangrove deforestation over the past four decades in Thailand has been high – a loss of around -$40 per person in real terms over 1970 to 2009. This amounts to an overall debit of over -$2.73 billion, which has never appeared in Thailand's national accounts.

Halting the decline in natural capital – including ecosystem loss – worldwide will require many more examples for different countries and regions, and for other key ecosystems, such as tropical forests, coral reefs, freshwater wetlands, grasslands, and so on.

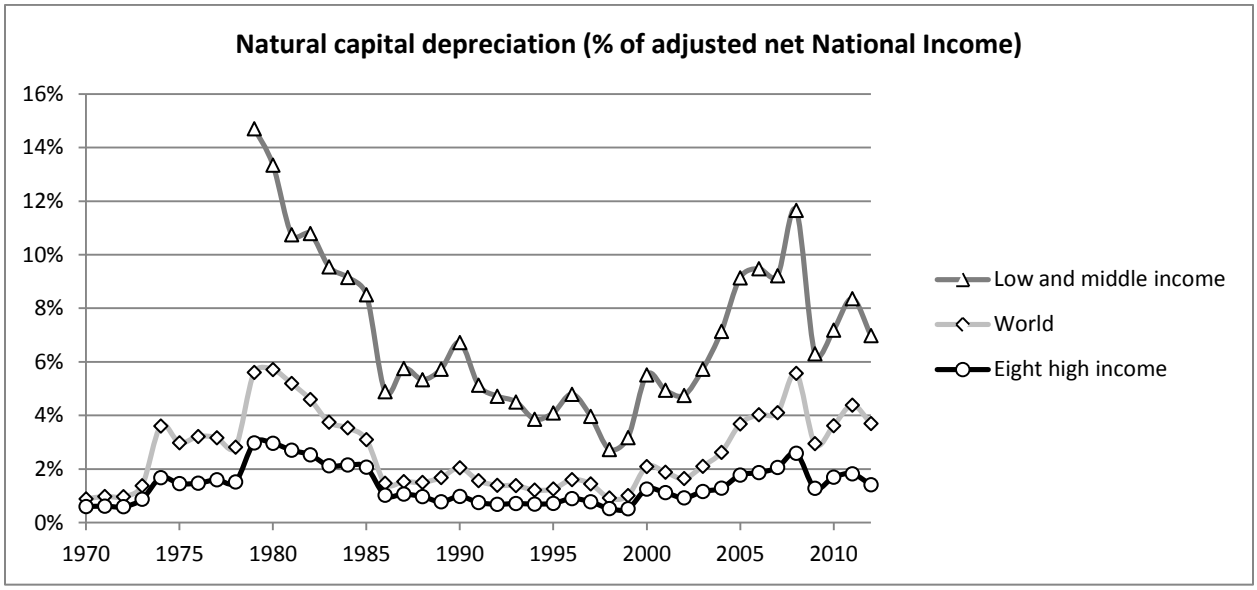
Two caveats. First, there are clearly intrinsic values to preserving unique natural resources, species and ecosystems, as well as the biological diversity contained in these systems, which cannot be captured by such an approach. Second, the benefits of many important ecosystem services have proven difficult to value. Our current measures of natural resource depletion also need to move beyond minerals, energy and timber harvests to include other vital resources, such as soils, air quality, aquifers, fisheries and non-timber forest resources. However, progress is currently being made. The UN *2012 Inclusive Wealth Report* has developed natural capital accounts over 1990-2008 for twenty countries that include not only minerals, energy and timber but also non-timber forest benefits, fisheries (for four countries only), carbon damages, and agricultural land. The World Bank is expanding pilot studies on ecosystem accounting from eight to 15 developing countries, which cover water, forest and mangrove ecosystems. We are also developing more reliable methods of valuing the various services of ecosystems. For estuarine and coastal ecosystems, there are already 80 valuation estimates from all over the world for storm protection, erosion control, water purification and supply, carbon sequestration, recreation, and maintenance of fishing, hunting and foraging activities – and the list is growing (Barbier 2013).

Although the UN and World Bank initiatives are encouraging, they are after all just pilot studies and involve only a few countries, natural resources and ecosystems. What we need is for the UN systems of national accounts to adopt a more systematic approach that all countries can adopt to account for natural capital and ecological capital losses, as we already do for fixed capital

depreciation (Figure 2). And, in the case, of complex ecosystems and landscapes, we need to resolve problems of 'double counting' ecosystem services that may serve as 'intermediate inputs' into production or are provided by multiple ecosystems (Barbier 2013).

Piketty may be right that, since 1970, there has been substantial accumulation of capital relative to income in the rich countries of the world. As low and middle-income countries try to emulate this success, they will be also striving to accumulate more wealth. But as my estimates show, our economies have been trading one form of capital – the earth's riches – for another – human riches. Without accounting accurately for this trade-off, we will continue to have a false impression of economic progress and growth. And, that is as dangerous as flying a plane into the night without navigation tools or instruments.

Fig. 1 The rate of natural capital depreciation, 1970-2012



The data used for these estimates are from the World Development Indicators.

Low and middle-income (or developing) countries are economies with 2012 per capita income of $12,615 or less.

The eight high-income countries are the United States, Japan, Germany, France, United Kingdom, Italy, Canada and Australia.

The measure of natural capital depreciation is the annual value of net natural resource depletion as a % of adjusted net national income (constant 2005 US$). The World Development Indicators define the value of net natural resource depletion as the sum of net forest, fossil fuel and mineral depletion. Net forest depletion is unit resource rents times the excess of roundwood harvest over natural growth. Energy depletion is the ratio of the value of the stock of energy resources to the remaining reserve lifetime (capped at 25 years). It covers coal, crude oil, and natural gas. Mineral depletion is the ratio of the value of the stock of mineral resources to the remaining reserve lifetime (capped at 25 years). It includes tin, gold, lead, zinc, iron, copper, nickel, silver, bauxite, and phosphate. Adjusted net national income is gross national income minus consumption of fixed capital and the value of net natural resources depletion, expressed in constant 2005 US$.

The average rate of natural capital depreciation worldwide over 1970-2012 was 2.7% worldwide, 1.7% in the eight high-income countries and 7.0% in developing countries (1979-2012).

Fig. 2. Adjusting National Income (NI) for reproducible, human, natural and ecological capital

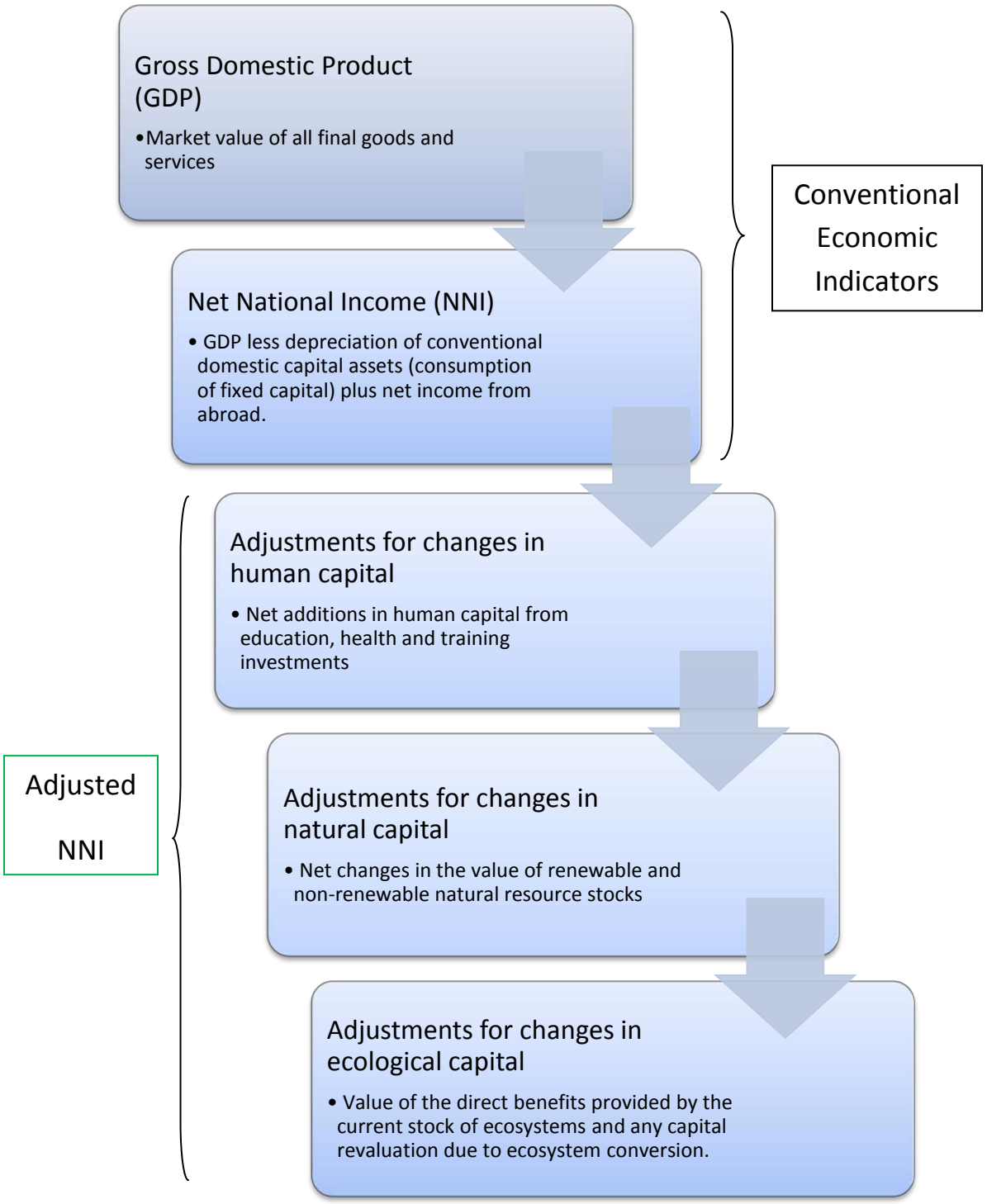


Table 1. Accounting for mangrove capital, Thailand, 1970-2009

			Average annual values per capita (constant 2000 US$)				
	Average annual mangrove loss (ha)	Average annual population growth (%)	Total value of remaining mangroves (1)	Net change in land value from mangrove conversion (2)	Net gain/loss in mangrove values (1)-(2) (3)	Value of mangroves with no deforestation (4)	Loss of value due to mangrove deforestation (4)-(3) (5)
1970-79	4,676	2.6%	0.57	-2.26	-1.69	0.61	-2.30
1980-89	2,980	1.9%	0.40	-1.16	-0.76	0.49	-1.25
1990-99	610	1.0%	0.32	-0.21	0.11	0.42	-0.31
2000-09	97	1.0%	0.28	-0.03	0.25	0.38	-0.13

Total value of remaining mangroves (column (1)) are the net subsistence benefits to local coastal communities from mangrove nursery and breeding ground support for off-shore fisheries and from wood and non-wood products collected from mangrove forests (e.g. shellfish, plants, honey, medicines, etc.), and carbon sequestration benefits. As storm protection value is based on expected damages to economic property, it is assumed that this benefit is already accounted for in the current market values of property.

Net change in land value from mangrove conversion (column (2)) is the difference between the capitalized value of mangroves converted to shrimp farms less the capitalized value of these mangroves if they were not converted. The latter valuation includes all current and future mangrove benefits from collected wood and non-wood products**,** nursery and breeding grounds for off-shore fisheries**,** storm protection, and carbon sequestration.

Value of mangroves with no deforestation (column (4)) 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 depicted in column (5), **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 2013.