An estimate of the Genuine Progress Indicator for Iceland, 2000-2019

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Abstract

Target 19 of the United Nations' Sustainable Development Goal 17 calls for the use of alternative measures of economic welfare in addition to Gross Domestic Product (GDP). The Genuine Progress Indicator (GPI) is an example of such a measure, including various non-market benefits and environmental and social costs unaccounted for in GDP. This study presents the results from the first estimate of the GPI for Iceland over the period 2000-2019. Iceland represents an interesting case study given its remoteness, environmental vulnerability, natural resource dependency, and fluctuating economic performance in recent years, which has featured a banking collapse and tourism-fuelled resurgence. The study finds that Iceland's GPI was equal to between 2.41 and 3.05 times the value of national GDP. Statistics for both GDP and the GPI peaked in 2019 at 2,970,076 (USD M 24,237) and 7,163,300 million ISK (USD M 58,443), respectively. Mean annual rates of per capita expansion for both GDP and the GPI were 2.1% and 0.6%, respectively. Despite the scale of the Icelandic GPI, the study also revealed non-negligible values for environmental and social costs which, in aggregate, were equal to between 17.8% and 25.4% of the value of consumption.

Keywords: economic welfare; alternative measure; genuine progress; Iceland; sustainable development

1. Introduction

A wide-ranging body of existing research questions the wisdom of using growth in Gross Domestic Product (GDP) as a yardstick of economic welfare and its progress (Costanza et al., 2016a; Costanza et al, 2016b; Coscieme et al., 2020; Coyle, 2014; Stiglitz et al., 2009;). The US Bureau of Economic Analysis asserted that GDP performance should be used to provide answers to the following questions: how fast is the economy growing; what is the pattern of spending on goods and services; and how much of the income produced is being used for consumption as opposed to investment or savings (McCulla and Smith, 2007). However, as Kuznets (1934) observed, GDP does not account for the total sum of economic activity within a nation, and the instigator of the System of National Accounts also advised against marrying GDP growth performance to economic welfare (Costanza et al., 2009). Kuznets (1934) voiced that GDP ignored earnings from the *"services of housewives and other members of the family"*, *"relief and charity"*, *"services of owned durable goods"*, *"earnings from odd jobs"*, and *"earnings from illegal pursuits"* (Kuznets, 1934, p. 3-5).

Stockhammer et al. (1997) and Costanza et al. (2009) noted that GDP is almost entirely a measure of national market-based production, albeit it includes some non-market aspects such as 'defensive' government spending on the military, health care and social housing. Indeed, many important economic activities are specifically excluded from the GDP calculation, including volunteer work, social formation, the costs of crime and an increasing prison population, and the depletion of natural resources (Costanza et al., 2009; Stern, 1996; Tol, 2014). Van den Bergh (2009) categorised eight shortcomings in the use of GDP as a measure of economic welfare:

- Principles of proper accounting – GDP is an estimate of the costs rather than the benefits of economic activities, and nor does it account for social costs.
- Intertemporal considerations – positive correlations between GDP growth and social welfare should not be assumed to persist into the future.
- Lexicographic preferences – growth in GDP and increases in material consumption are imperfect compensation for poorly satisfied basic human needs such as access to clean air or unspoiled nature.
- Empirical studies of happiness – beyond a certain threshold, the costs of economic growth appear to exceed the benefits, as demonstrated via the Easterlin Paradox.
- Income distribution, relative income and rivalry for status – GDP per capita represents the average outcome rather than its distribution and it is thus inconsiderate of implications with regards to status attained via consumption.
- Formal versus informal economy – GDP overlooks non-market, non-price activities such as voluntary work and childcare.
- Environmental externalities and depletion of natural resources – market prices for certain goods (e.g., fossil fuel production) fail to reflect social costs, and the costs of pollution clean-up are classed as a benefit to society rather than a debit; additionally, neither natural nor physical capital depletion is not accounted for in GDP.

The limitations of economic growth led the United Nations to include a call within Target 19 of Sustainable Development Goal (SDG) 17 for the development of measurements of progress on sustainable development that complement GDP (UN, 2015). This was echoed in the recent paper by Coscieme et al. (2020, p. 6) which opined that *"measuring progress towards SDG 8 needs to consider further macro-economic indicators that internalize social and environmental externalities"*. In recent years, a global movement has indeed begun to grow, striving to expand macroeconomic analysis beyond its focus on marketed goods and services to embrace the broader aspects of economic welfare (Costanza et al., 2018, New Zealand Treasury, 2019; WEA, 2019). Alternative measures of economic welfare provide a more nuanced analysis of economic progress, particularly through accounting for the costs and benefits of the services of benefit to human well-being and the damages associated with economic activity, including inequality, pollution and crime. (Coscieme et al., 2020; Costanza et al., 2014; Costanza et al., 2016a; Costanza et al., 2016b).

A popular alternative measure is the Genuine Progress Indicator (GPI), which is supplementary to GDP (Hoekstra, 2019; Cook and Davíðsdóttir, 2021a). The GPI has been widely applied around the world in both a national, state and city-based context, especially in the United States (Bagstad et al., 2014). The measures aims to provide *"a monetary measure of economic welfare for a given population in a given year that accounts for benefits and costs experienced by that population in association with investment, production, trade, and consumption of goods and services"* (Talberth and Weisdorf, 2017, p. 142). Cook and Davíðsdóttir (2021a) found, based on a review of five alternative measures of economic welfare, that the GPI's methodology was aligned with objectives in fourteen of the seventeen SDGs. Seeking to account for market-based welfare, services from essential capital, and the environmental and social externalities of economic activity, the GPI has the capacity to overcome many of Van den Bergh's (2009) concerns about GDP, highlighting many of the economic, environmental and social costs of pursuing economic growth, and potentially incentivising government action to ameliorate these (Cook and Davíðsdóttir, 2021a).

This paper aims to add a new national GPI case study to the academic literature. The remote and very sparsely populated island of Iceland represents an interesting case study for analysis. Iceland is geologically the youngest nation on the planet, and it continues to be shaped simultaneously by the forces of volcanism and glaciation (Ólafsdóttir and Dowling, 2014; Ólafsson et al., 2014; Ilyinskaya et al., 2016). The extremes of nature have been mirrored in the tumultuous character of Iceland's national economy these past two decades. From the banking and currency-value collapse of 2008, one of the largest in history, to the tourism boom which led to the nation attaining the fastest rate of GDP growth (7.2%) among OECD members in 2016 (OECD, 2017; Loftsdóttir et al. 2018), to the ongoing economic collapse of its key tourism sector during the COVID-19 crisis of 2020 (Sigurðardóttir, 2020), the macroeconomic performance of Iceland has rarely been stable or predictable. The economy has been especially reliant on natural resources for export-related income (Krausmann et al., 2014; Nielsen et al., 2018) and ecosystem services, particularly in relation to nature-based tourism (Cook et al., 2019; Sæþórsdóttir and Hall, 2019). However, little is known about the broader welfare implications of Iceland's economic activities, including the non-market benefits sourced from the nation's stocks of essential capital, and the economic, environmental and social costs and benefits.

The objectives of this paper are twofold:

1) To provide an estimate of Iceland's GPI over the period 2000–2019, comparing outcomes to GDP.
2) To identify the main cost and benefit components within the GPI and trends over the period 2000–2019.

This paper is structured as follows. Section 2 sets out the methodology for the calculation of the Icelandic GPI. Section 3 outlines the overall results, focusing on the differences between

GPI and GDP performance and analysing the main cost and benefit components. Section 4 discusses the implications of the study in relation to policy-making and considers some of the methodological challenges pertaining to the estimation of Iceland's GPI. Section 5 provides a brief conclusion and reflects on avenues for future research.

2. Methodology

2.1 Theoretical underpinnings of the GPI

The GPI has been defined in various ways since its inception as a successor to the Index of Sustainable Economic Welfare in the 1990s. Talberth and Weisdorf (2017) summarise three of the main definitions of the GPI: an index of sustainable economic welfare with theoretical foundations based on the notion of maximum sustainable income as per Hicks (1946); a social welfare measure focused on the concept of 'psychic income' as per Fisher (1906) or 'entropic net psychic income' as per Brennan (2008); and an aggregation of sub-indicators that provides information about current economic welfare and gives an indication as to the sustainability of economic activities.

Contention about how the GPI is defined has led to the deployment of various ad hoc methods being utilised in its calculation. Talberth and Weisdorf (2017) attempted to clarify the debate, asserting that any definition of the GPI should encapsulate four core aspects: (1) emphasis on final consumption of market and non-market goods and services by a given population; (2) focus on current economic welfare generated by that consumption; (3) restriction on costs and benefits to only those causally linked to economic activities; and (4), monetisation must be carried out using peer reviewed methods, consistent valuation rules, and best available data. The four criteria restrict the analysis to costs and benefits experienced in a certain place and at a certain time.

2.2 Calculation of the Icelandic GPI

This study adhered to the calculation procedure set out by Talberth and Weisdorf (2017) (equation 1; Table 1), which, for a given time period and population, aggregates net utility from consumption of market-based goods and services to utility from essential capital, then deducts disutility linked to undesirable social and environmental conditions. As per the observation of Van der Slycken and Bleys (2020), this is a common approach to the calculation of many measures of economic welfare, but it is important to acknowledge that it does not account for future costs, costs shifted abroad and capital changes.

Equation (1):

$$GPI_t = \frac{1}{N}\sum_{i=1}^{N}\Big[U_i\big((HBE_1 - DEFR - HI_i) \times INQ + PP\big)_i + U_i\big(s(KH_i + KS_i + KB_i + KN_i)\big) - dU_i(DKN_1 + POL_i + SC_i)\Big]$$

Where:

U is utility
dU is disutility

Table 1. GPI calculation components in equation (1).

Theoretical component	**Utility from consumption of goods and services**	**Utility sourced from essential capital**	**Disutility linked to undesirable environmental and social conditions**
Functional form	$U_i\big((HBE_1 - DEFR - HI_i) \times INQ + PP\big)_i$	$U_i\big(s(KH_i + KS_i + KB_i + KN_i)\big)$	$dU_i(DKN_1 + POL_i + SC_i)$
Sub-category	HBE = household budget expenditures DEFR = defensive and regrettable expenditures HI = household investments INQ = inequality adjustment PP = public provision of goods and services	s = services KH = services from human capital KS = services from social capital KB = services from built capital KN = services from natural capital	DKN = depletion of natural capital POL = pollution SC = social costs of economic activity

Often there are considered to be five capital stocks providing service flows of value to well-being: human, social, built (sometimes called physical or man-made), financial and natural. Financial capital, however, is already contained within market-based net utility from consumption of goods and services. Therefore, its inclusion in the utility from essential capital category would entail double counting.

For the purposes of this study, the four capital stocks were defined in accordance with the well-being economy study of Cook and Davíðsdóttir (2021a):

Human – the capabilities and capacities of human beings to engage in work, study, recreation and social activities; includes skills, knowledge, and physical and mental health.

Social – the norms, rules and institutions that influence the ways in which people live and work together and experience a sense of belonging; includes trust, reciprocity, the rule of law, cultural and community identity, traditions and customs, common values and interests.

Built – physical assets which support material living conditions; includes factories, roads, hospitals, houses, consumer durables etc.

Natural – all aspects of the natural environment that support life and economic activities, including land, soil, water, plants and animals, minerals and energy resources.

Note that the GPI specifically focuses on monetary values of service flows (using sub-indicators) linked to capital asset stocks. This is to ensure that the indicator maintains adherence with Fisher's concept of psychic income and current economic welfare, not the potential for diminished well-being in the future. Other alternative measures of welfare, such as the Inclusive Wealth Index, and biophysical indicators, focus on changes in capital stocks and are thus designed to focus more on long-term sustainability considerations than current economic welfare implications (Lawn, 2013). Given this, modern versions of the GPI tend to omit two adjustments common to earlier studies – net capital investment and net foreign lending and borrowing – on the basis that these express changes in financial capital stocks rather than flows of relevance to current economic welfare (Talberth and Weisdorf, 2017).

2.3 Selected sub-indicators in Icelandic GPI

Table 2 sets out the 38 sub-indicators specific to the categories of economic welfare captured by equation (1), together with details of the capital assets linked to each sub-indicator, summary details of the calculation method, and data sources. Much of the data was collected from online repositories at Statistics Iceland, the main official government data institute. The number and comprehensiveness of the sub-indicators compares favourably with recent national GPI studies, such as the ones by Kenny et al. (2019) on Australia and Patterson et al. (2019) on New Zealand, which were comprised of 26 and 21 sub-indicators, respectively. It is slightly lower than the 43 sub-indicators included in the US GPI 2.0 pilot study by Talberth and Weisdorf (2017), the reasons for which are outlined in the discussion.

All nominal values and those sourced in years, other than 2019, were converted to 2019 Icelandic prices for the purposes of standardisation. Data on the national population were obtained from Statistics Iceland, enabling per capita comparisons to be reported for GDP and the GPI, and the three main categories in the GPI: market-based welfare, services from capital assets, and the environmental and social costs of economic activity.

Efforts were made to avoid the potential double counting of benefits in the calculation, particularly with respect to benefits from essential capital stocks. For example, the value of internet services could be included within the services pertaining to the social capital class, but such inclusion would duplicate its value within household expenditure. Equally, the value of household work has commonly been included in earlier GPI studies, but its inclusion could have duplicated part of the benefits encompassed within the value of leisure time. The same is true of the economic value of provisioning services within the ecosystem services pertaining to Iceland’s natural capital. A more detailed reflection on the methodology, including the choosing of data sources, methods, and excluded or omitted variables, is set out in the discussion.

Table 2. Sub-indicators used in the calculation of Iceland's GPI.

Sub-indicator	Type of capital	Summary of calculation method (all values adjusted to 2019 Icelandic prices)	Operation	Data source(s)
Utility from consumption of goods and services				
Household budget expenditures (HBE) and defensive and regrettable expenditures (DEFR)	Financial	Household final consumption expenditure (HFCE).	Addition	Statistics Iceland (2020a)
Costs of food waste	Human	Derived from estimate of the aggregate economic value (market price) of food waste in the capital area in 2016 (Environment Agency, 2016), scaled to the size of the Icelandic population.	Deduction	Environment Agency of Iceland (2016)
Insurance	Financial	Derived from itemised HFCE.	Deduction	Statistics Iceland (2020a)
Welfare neutral goods	Human	Derived from itemised HFCE. Followed assumption of Lawn (2013) that 25% of alcohol consumption and 80% of tobacco and narcotics consumption were purchases likely to be welfare declining.	Deduction	Statistics Iceland (2020a) / Lawn (2013)
Costs of family changes	Human / Social	Benefit transfer approximation based on estimate by Spitzer (2017) concerning mean costs of divorce in the US ($15,000 per person), multiplied by number of Icelandic divorces per annum.	Deduction	Spitzer (2017) / Statistics Iceland (2020b)
Costs of maintaining dwelling services	Built	Derived from itemised HFCE – water infrastructure and other dwelling services e.g. waste.	Deduction	Statistics Iceland (2020a)
Household investments (HI)				
Consumer durables	Built	Aggregated value of purchases of cars, houses and appliances in HFCE from previous five years multiplied by 0.2 as per approach of Kenny et al. (2019).	Deduction	Statistics Iceland (2020a) / Kenny et al. (2019)
Household repairs and maintenance	Built	Derived from itemised HFCE.	Deduction	Statistics Iceland (2020a)
Goods and services for household repairs and maintenance	Built	Derived from itemised HFCE.	Deduction	Statistics Iceland (2020a)
Income inequality adjustment (INQ)	Financial	Index-derived adjustment based on extent of the Gini coefficient deviation from baseline – lowest year of income inequality given a base value of 100.	Deduction	Statistics Iceland (2020c)
Public provision of goods and services (PP)				
Education	Human	Itemised expenditure by central government in GDP calculation.	Addition	Statistics Iceland (2020e)
Healthcare	Human	Itemised expenditure by central government in GDP calculation.	Addition	Statistics Iceland (2020e)
Local government services	Human and social	Itemised expenditure by local government in GDP calculation, relating to health, education, recreation, social protection, housing and community amenities, environmental protection, public order and safety, defence and other public services.	Addition	Statistics Iceland (2020e)
Utility sourced from essential capital				
Services from human capital (KH)				
External benefits from higher education	Human	Benefit transfer approach – annual number of Icelandic college graduates (ISCED (2011) Levels 5-8) multiplied by annual social payoff as per Talberth et al. (2007) study.	Addition	Statistics Iceland (2020g) / Talberth et al. (2007)

Research and development	Human	Annual government expenditure in GDP calculation on research and development in economic and labour affairs; agriculture, forestry and fishing; fuel and energy; mining, manufacturing and construction; and other industries.	Addition	Statistics Iceland (2020e)
Services from social capital (KS)				
Value of leisure time	Social	To calculate the measure for leisure time, the method outlined by Talberth et al. (2007) was utilised, leading to an imaginary base year with mean leisure time of 1,770 hours per person (derived by assuming a 40-hour work week and five weeks of annual vacation time for a total of 235 working days). Adjusted mean leisure time per person was multiplied by the total number of workers in the labour force to arrive at a total number of leisure hours for the nation per annum, which was multiplied by the mean gross hourly wage rate in the private sector.	Addition	Statistics Iceland (2020d; 2020f) / Talberth et al. (2007)
Value of unpaid labour in the volunteering sector	Social	Although data is limited for Iceland, the most recent completed study of the World Values Survey, Wave 4, estimated that 29% of Icelanders took part in voluntary work in 2014. Scaled to the Icelandic population and assuming mean volunteering hours of 89 per volunteer per year in line with the US national estimate of 2018, the total number of Icelandic volunteering hours was multiplied by the mean gross hourly wage rate in the private sector.	Addition	AmeriCorps (2018) / World Values Survey (Inglehart et al., 2014) / Statistics Iceland (2020d)
Recreation, culture and religion		Annual national government expenditure in GDP on recreation, culture and religion.		Statistics Iceland (2020e)
Community development		Annual national government expenditure in GDP on community development.		Statistics Iceland (2020e)
Services from natural capital (KN)				
Services from preserved nature	Natural	Uses outcome from the study of Cook and Davíðsdóttir (2021b), which provides an estimate of the economic value of Iceland's ecosystem services using the benefit transfer approach, CORINE land use classes and land cover data for Iceland, and monetary unit values for specific biomes from the Ecosystem Services Valuation Database.	Addition	National Land Survey of Iceland (2018) / Cook and Davíðsdóttir (2021b)
Services from built capital (KB)				
Value of transportation infrastructure	Built	Aggregated annual government expenditures in GDP on road, water and air transportation, infrastructure and maintenance.	Addition	Statistics Iceland (2020e)
Value of energy and water infrastructure	Built	Aggregated annual government expenditures in GDP on electricity, non-electric energy generation and the water supply.	Addition	Statistics Iceland (2020e)
Waste treatment by sewer infrastructure	Built	Aggregated annual government expenditures in GDP on waste and water waste management.	Addition	Statistics Iceland (2020e)
Housing development	Built	Aggregated annual government expenditures in GDP on housing development.	Addition	Statistics Iceland (2020e)
Manufacturing	Built	Aggregated annual government expenditures in GDP on manufacturing.	Addition	Statistics Iceland (2020e)
Construction	Built	Aggregated annual government expenditures in GDP on construction.	Addition	Statistics Iceland (2020e)
Disutility linked to undesirable environmental and social conditions				
Depletion of natural capital (DKN)				
Non-renewable resource depletion	Natural	Nominal replacement cost of biomass fuel in barrels of oil equivalent as per study of Babcock (2017) ($81.3 in 2019 prices) multiplied by volume of fossil fuels (oil and coal) in primary energy in Iceland in barrels of oil equivalent.	Deduction	National Energy Authority of Iceland (2020) / Babcock (2017)

Ozone depletion	Natural	Emissions of HFCs in tonnes carbon dioxide equivalent multiplied by the social cost of carbon using the mean outcome from the meta-analysis of Wang et al. (2019).		UNFCCC (n.d.) / Wang et al. (2019)
Overharvesting of fisheries	Natural	Difference between total catch and total allowable catch multiplied by value of catch per tonne.	Deduction	Icelandic Directorate of Fisheries (2020) / Statistics Iceland (2020j)
Avoided depletion	Natural	Avoided depletion costs approximated by annual government expenditure in GDP on protection of biodiversity and landscape.	Deduction	Statistics Iceland (2020e)
Pollution (POL)				
Air pollution	Natural	Economic cost of mortality impact calculated by number of premature deaths from outdoor (particulate matter and ozone) and indoor air pollution (Ritchie & Roser, 2019) multiplied by average cost of each death from air pollution using the value of statistical life (VSL) measure, estimated for Iceland by the World Health Organization in 2010.	Deduction	Ritchie and Roser (2019) / WHO Regional Office for Europe, OECD (2015)
Climate change contribution	Natural	Quantity of man-made greenhouse gas emissions multiplied by average social cost of carbon using the mean outcome from the meta-analysis of Wang et al. (2019).	Deduction	UNFCCC (n.d.) / Wang et al. (2019)
Solid waste	Natural	Volume in tonnes of total waste generation multiplied by external cost of Icelandic waste generation in the study of Kinnaman (2009). Note that total waste generation has only been reported in Iceland since 2014, however, municipal waste volumes were reported throughout the assessment period. Derived from the mean proportion of total waste constituting municipal waste (19.1%) from 2014 onwards, municipal waste data was upscaled for 2000-2013 to estimate total waste generation.	Deduction	Statistics Iceland (2020k) / Kinnaman (2009)
Avoided damages	Natural	Avoided costs to human well-being approximated by annual government expenditure in GDP on pollution abatement.	Deduction	Statistics Iceland (2020e)
Social costs of economic activity (SC)				
Unemployment	Social	Total unprovided hours of individuals aged 16-74 multiplied by gross mean private sector wage (ISK/hr).	Deduction	Statistics Iceland (2020d; 2020f; 2020h)
Crime	Social	Total annual government cost of operating prisons and law courts in Iceland.	Deduction	Statistics Iceland (2020e)
Commuting	Human	Aggregation of direct cost of commuting, indirect time spent commuting to work, and direct costs of public transportation. Commuting cost calculated by multiplying annual commuting distance by cost of driving per km and the number of vehicles owned by households. Cost per one km of driving was calculated through the calculation of average cost of fuel per km in Iceland (Global Petrol Prices, 2020) Indirect cost of commuting times was obtained by the approximate amount of time spent reaching work multiplied by the mean gross hourly wage for full-time work in the private sector.	Deduction	Statistics Iceland (2020d; 2020i); Reynarsson (2008); Global Petrol Price (2020)
Vehicle accidents	Social	Approach of Kubiszewski et al. (2015) was followed, whereby cost of vehicle accident equalled number of deaths (Samgöngustofa, 2020) multiplied by cost per accident. The road administration conducted a study in 2013 on the cost of deaths in a car accident (Sigþórsson & Hilmarsson, 2014). The research calculated not only individual cost, but also reflected the social cost of an accident to arrive at an estimated VSL.	Deduction	Kubiszweski et al. (2015); Samgöngustofa (2020); Sigþórsson and Hilmarsson (2014)

3. Results

3.1 Overall trends

Figures 1 and 2 provide a comparison of outcomes between Iceland's GDP and GPI over the period 2000-2019. Figure 1 depicts values in 2019 Icelandic prices, while Figure 2 shows these on a per capita basis. Table 3 outlines the numeric category, total and per capita values for GDP and the GPI. Figure 3 provides a breakdown of the size and trajectories of the core GPI component categories detailed in Equation (1): market-based welfare, services from essential capital, and environmental and social costs. The analysis subsequent to Figure 3 also includes million US dollar (USD M) equivalent values for all amounts stated in million ISK.

Figure 1. Icelandic GDP versus GPI, 2000-2019 (million ISK, 2019 prices).

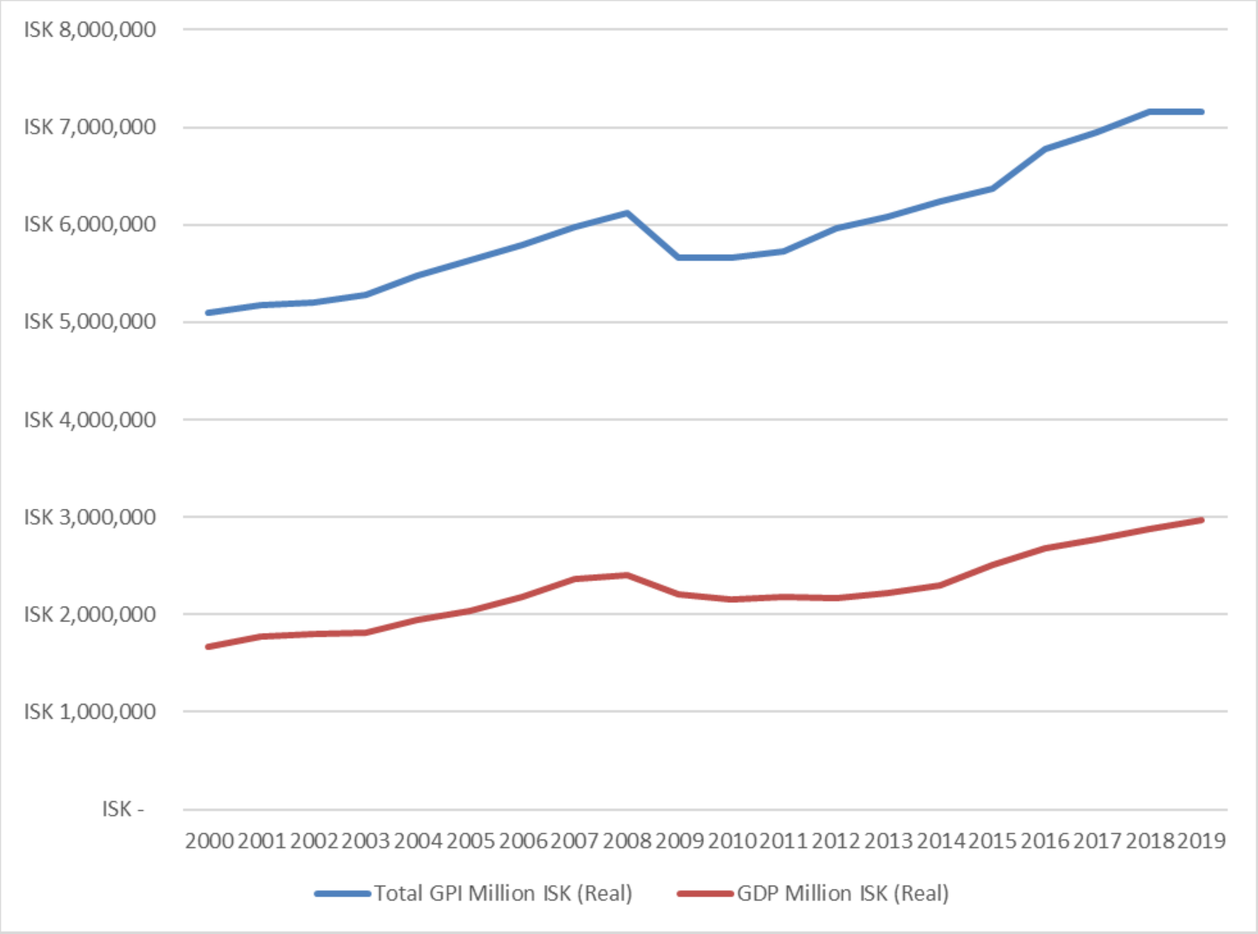

Figure 2. Icelandic GDP versus GPI, 2000-2019 (million ISK per capita, 2019 prices).

Figure 3. Icelandic GPI Components, 2000-2019 (million ISK, 2019 prices).

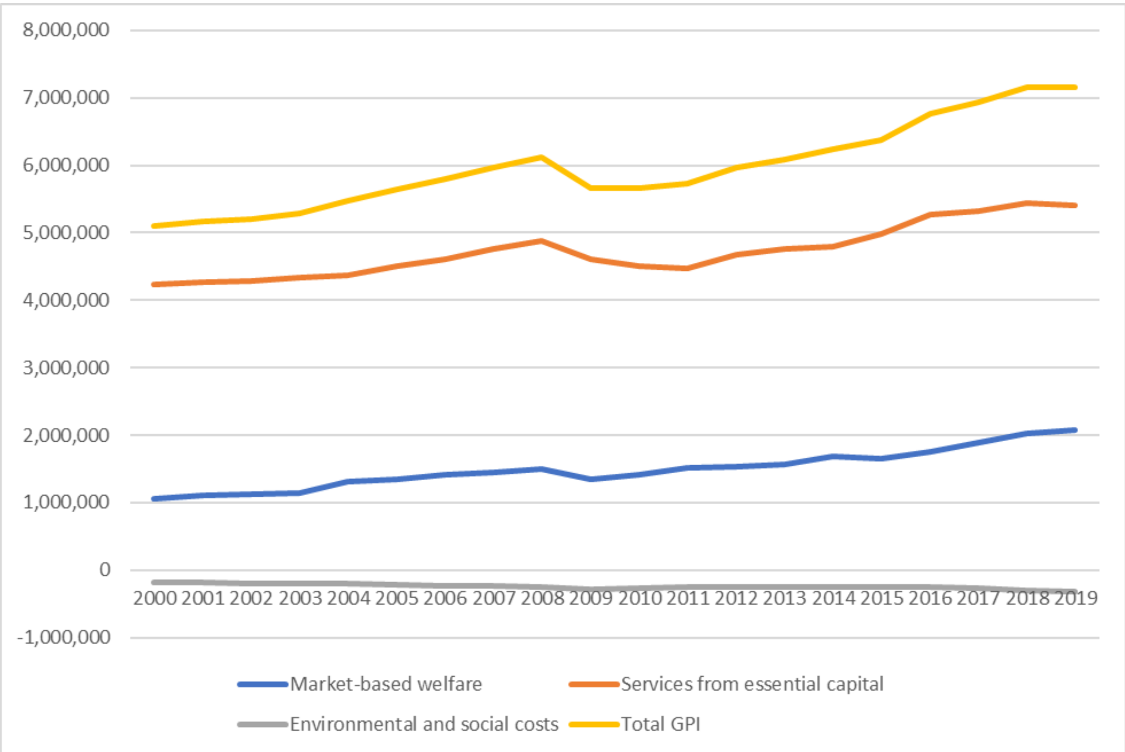

Table 3. GPI component analysis and comparison to GDP (million ISK, 2019 prices).

Year	Utility from goods and services	Services from capital assets	Environmental and social costs	GPI	GDP	Population	GPI per capita	GDP per capita
2000	1,054,854	4,227,018	(189,856)	5,101,318	1,670,984	279,049	18.28	5.99
2001	1,090,225	4,262,533	(186,304)	5,176,596	1,773,650	283,361	18.27	6.26
2002	1,106,456	4,279,341	(200,328)	5,196,826	1,796,830	286,575	18.13	6.27
2003	1,135,696	4,336,577	(202,038)	5,283,081	1,808,617	288,471	18.31	6.27
2004	1,297,725	4,366,931	(201,250)	5,477,884	1,943,738	290,570	18.85	6.69
2005	1,335,986	4,500,463	(214,685)	5,636,376	2,037,955	293,577	19.20	6.94
2006	1,397,970	4,614,559	(229,695)	5,797,269	2,179,409	299,891	19.33	7.27
2007	1,436,323	4,758,671	(236,211)	5,972,655	2,365,231	307,672	19.41	7.69
2008	1,493,399	4,873,274	(254,628)	6,125,298	2,400,200	315,459	19.42	7.61
2009	1,291,614	4,605,638	(288,139)	5,661,046	2,211,116	319,368	17.73	6.92
2010	1,409,171	4,505,990	(270,210)	5,657,843	2,155,912	317,630	17.81	6.79
2011	1,501,478	4,469,333	(257,086)	5,728,042	2,178,303	318,452	17.99	6.84
2012	1,513,725	4,682,104	(249,318)	5,960,926	2,169,625	319,575	18.65	6.79
2013	1,546,555	4,768,886	(251,135)	6,079,323	2,221,106	321,857	18.89	6.90
2014	1,669,227	4,798,312	(245,610)	6,238,520	2,304,941	325,671	19.16	7.08
2015	1,627,247	4,983,932	(250,672)	6,376,538	2,509,765	329,100	19.38	7.63
2016	1,740,321	5,270,145	(253,828)	6,773,850	2,679,731	332,529	20.37	8.06
2017	1,866,742	5,327,184	(268,476)	6,943,110	2,766,821	338,349	20.52	8.18
2018	2,000,407	5,435,071	(293,899)	7,159,869	2,871,201	348,450	20.55	8.24
2019	2,064,701	5,404,795	(323,937)	7,163,300	2,970,076	356,991	20.07	8.32

Across the entirety of the assessment period, the GPI was always higher than GDP, and the same is evident with respect to the per capita statistics. The Icelandic GDP and GPI both peaked in 2019 at values of 2,970,076 (USD M 24,237) and 7,163,300 (USD M 58,443 M) million ISK, respectively. GDP per capita was highest in 2019, whereas the per capita peak for the GPI occurred a year earlier. Over the period 2000-2019, Icelandic GDP increased by 1,299,092 million ISK (USD M 10,601), an average annual growth rate of 4.1%. GDP per capita increased by 2.06 million ISK (USD M 0.02) from 2000-2019, a mean annual expansion of 2.1%. With respect to the GPI during this period, this measure grew by 2,061,982 million ISK (USD M 16,823), an average annual expansion of 2.2%. GPI per capita increased by 1.95 million ISK (USD M 0.02) from 2000-2019, a mean annual expansion of 0.6%. The divergence between the GPI and GDP was fairly consistent, and always within a ratio of between 2.41 and 3.05. It was highest at the start of the assessment period, in 2000, and lowest at its end, in 2019.

Icelandic GDP increased year-on-year until 2008, when it reached a decadal peak value of 2,400,200 million ISK (USD M 19,582). Thereafter, in the aftermath of the national banking collapse, it declined by 10.2% to a value of 2,155,912 ISK (USD M 17,589) in 2010, not recovering to its 2008 level until 2015, when the nation’s tourism boom was in full swing. The same pattern was evident in the per capita data. The GPI also increased year-on-year until 2008 when it reached a decadal high of 6,125,298 million ISK (USD M 49,974). Thereafter, it declined by 7.2% to 5,661,046 million ISK (USD M 46,186) in 2009, not returning to its 2008 level until 2013. The decline in the GPI was steeper than GDP and its recovery was swifter. GPI per capita was slightly different, not returning to its 2008 level until 2015, which therefore matched with the trajectory of GDP per capita. Following the nation’s recovery from the 2008 collapse, the fastest rates of growth in the Icelandic GDP and GPI across the whole assessment period were evident. From 2013 onwards, the Icelandic GPI grew by 1,083,977 million ISK (USD M 8,844), an average annual growth rate of 3.0% from 2013-2019. GDP increased by 748,970 million ISK (USD M 6,111) after 2015, an average annual growth rate of 5.6%.

Overall, there were two years in which Icelandic GDP reduced from its value in the previous year: 2009 and 2010. The GPI reduced significantly in 2009 compared to 2008, but it otherwise always increased. Per capita data was subject to greater flux from one year to the next. GDP per capita fell on four occasions: 2008, 2009, 2010 and 2012. The GPI per capita reduced on four occasions too: 2001, 2002, 2009 and 2019. The year 2009 was a nadir for the Icelandic economy, which is reflected in it being one of only two annual periods (a very small decline occurred in 2013) when utility from goods and services reduced.

3.2 Utility from consumption of goods and services

This category of economic welfare followed similar trends to GDP and the GPI, increasing year-on-year from 2000 to 2008, before declining significantly in 2009 and not reaching its former level until 2011. From 2010 onwards, utility from the consumption of goods and services increased year-on-year, rising to 655,530 million ISK (USD M 5,348) in 2019, 46.5% higher than at the start of the decade. The 2019 peak of 2,064,071 million ISK (USD M 16,840) was almost double the figure of 1,054,854 million ISK (USD M 8,606) in 2000, equating to an average annual increase of 5.0% across the assessment period. The years 2009 and 2015 were the only ones involving a reduction in utility from the consumption of goods and services, most strikingly in 2009 when there was a decline of 201,785 million ISK (USD M 1,646), a 13.5% reduction. Across the whole assessment period, utility from consumption of goods and services constituted between 20.9% and 28.9% of the GPI, the percentage being lowest in 2000 and highest in 2019. Although a direct comparison with GDP is not possible due to the presence of deductions in the calculation, this category of economic welfare was equivalent to between 58.4% and 72.4% of GDP. It was lowest in 2009 and highest in 2014.

The most significant component in this category was HFCE. As is customary, HFCE comprised the largest share of GDP, contributing between 49.6% (in 2016) and 59.4% (in 2000) of its aggregation. With respect to the GPI, there was little variability, with HFCE in the range of 19.0% (in 2002) to 22.5% (in 2007) of the total value. As a component of utility from the consumption of goods and services, HFCE played a dominant but declining role due to increased deductions for welfare declining aspects and greater expenditure on public provision of services. In the year 2000, HFCE amounted to 94.1% of the category's total, which remained as high as 92.2% in 2007, before the year-on-year percentage declined from 2011, falling to a low of 72.8% in 2019. When calculated on a per capita basis, HFCE peaked in 2007 at 4.3 million ISK (USD M 0.04), and then dropped until 2010, reducing by 18.6% to 3.5 million ISK (USD M 0.03), and in 2019 it was still 0.09 million ISK per capita shy of its 2007 level.

Defensive and regrettable expenditures formed a relatively small deduction, equating to between 4.5% and 5.3% of HFCE. The amounts were in the range 48,628 to 68,141 million ISK (USD M 397 to 556), being lowest in 2000 and highest in 2018. The biggest contributor to defensive and regrettable expenditures was the proportion of purchases on alcohol and narcotics that were deemed to be welfare declining. These were highest in 2018 at 27,399 million ISK (USD M 224), but never lower than 24,510 million ISK (USD M 200) across the assessment period. Deductions against HFCE for household investments were higher throughout than the aggregated value of defensive and regrettable expenditures. These were in the range 62,413 to 148,618 million ISK (USD M 509 to 1,213), lowest in 2009 and highest in 2007. Viewed as a percentage of HFCE, household investments were also lowest in 2009 at 5.5% and highest in 2005 at 12.2%. Year-on-year growth in household investments occurred from 2009 to 2017, followed by two years of decline in 2018 and 2019. The size and variability of deductions for consumer durables greatly influenced the overall scale of household investments. In 2007, for example, consumer durables amounted to 82,349 million ISK (USD M 672), 55.4% of all household investments in that year.

The other deduction in the calculation of utility from the consumption of goods and services was income inequality. This was lowest in 2014, when the Gini coefficient was 0.227, and thus in this year no further adjustment was made to HFCE net of defensive and regrettable expenditures and household investment, since an index value of 100.0 was applied. Income inequality in Iceland is one of the lowest in the world and the Gini coefficient has been below 0.25 every year since 2010. The Gini coefficient was highest in 2009 at 0.296, leading to a 30.4% adjustment to net HFCE. It declined considerably in 2010 and 2011, suggesting lag effects after the financial crash of 2008. The high level of relative income inequality in 2009 is one of the main variables underpinning that year's decline in utility from the consumption of goods and services, the GPI aggregation, and GPI per capita. Against HFCE in 2009, the adjustment for income inequality amounted to 263,932 million ISK (USD M 2,153), which accordingly reduced the aggregate value of utility from the consumption of goods and services by 18.9%.

For all years in the assessment period, the value for utility from the consumption of goods and services was in excess of HFCE once defensive and regrettable expenditures, household investments and income inequality had been deducted. The reason for this was the additional contribution of expenditure on public provision of goods and services. Aggregating national and local government expenditures, these were in the range 349,297 to 821,106 million ISK

(USD M 2,850 to 6,699), lowest in 2000 and peaking in 2019. On a per capita basis, these were also lowest in the year 2000, at 1.3 million, and highest in 2019, at 2.3%. Although local government expenditures across Iceland constituted the largest share of public provision of services, in the range of 48% to 72%, recent growth in this component has been driven by increased national government expenditure on healthcare and education. Compared to the year 2000, there was a 229% increase in combined national government expenditures on healthcare and education, equating to an average expansion of 12.1% per annum. Per capita expenditures on healthcare and education were both more than three times higher in the year 2019 than in 2000.

3.3 Utility sourced from capital assets

The GPI was dominated by non-market contributions that are predominantly excluded from GDP. Aggregate services from the four capital asset classes amounted to between 1.82 (in 2019) and 2.53 times (in 2000) the value of Icelandic GDP. Apart from the years 2003, 2008, 2009, 2010 and 2012, the ratio of aggregated services value to GDP declined on the previous year. The value of aggregate services from the four capital assets increased year-on-year until 2008, when they reached 4,873,274 million ISK (USD M 39,759), at which point three consecutive years of decline occurred. It was not until 2015 that the value of aggregate services reached and exceeded its 2008 level, eventually peaking in 2018 at 5,435,071 million ISK (USD M 44,343). Viewed from a per capita perspective, there is relatively little variability, although it is evident that a decadal peak of 15.5 million ISK per person in 2007 was followed by three consecutive years of decline to an assessment period low of 14.0 million ISK (USD M 0.11) per person in 2011. Thereafter, there was a steady increase to a high of 15.8 million ISK (USD M 0.13) per person in 2016, and gradual decline in the period thereafter.

The composition of the aggregate value is dominated by ecosystem services from natural capital, which were 3,209,476 million ISK (USD M 26,185) throughout. These were based on a single estimate of the economic value of Iceland’s ecosystem services by Cook and Davíðsdóttir (2021b). Therefore, compared to GDP, which has grown over the assessment period, the scale of the economic value of Iceland’s ecosystem services has reduced over time. Examined as a ratio of services value to GDP, the economic value of Iceland’s natural capital was 1.92 times greater than GDP in 2000, with a 1.08 scale factor in 2019. In almost all years the ratio declined, except for 2009 and 2010, when a contraction in GDP occurred. As a proportion of the total service value, ecosystem services from natural capital constituted 75.9% in 2000 and 59.4% in 2019. The percentage declined every year apart from 2008 to 2010 inclusive.

The second most significant capital asset in the total service value was social capital. The value of services from social capital followed a similar trajectory to some of the other components, increasing year-on-year until 2008 when it reached a decadal high of 1,452,354 million ISK (USD M 11,849), before declining in 2009 and 2010, and not returning to its 2008 level until 2015. The peak value occurred in 2018 when services were estimated to be worth 1,938,201 million ISK (USD M 15,813). As a percentage of the total service value across all four capital assets, services from social capital represented between 20.6% (in 2000) and 35.7% (in 2018). The value of leisure time amounted to between 94.6 and 96.4% of the total value of social capital services throughout the assessment period. Most of the growth in the economic value of social capital can be ascribed to increases in the economic value of leisure time, which has been driven to a considerable extent by population growth. However, even when calculated on a per capita basis, the economic value of services from social capital were highest in the years 2016 to 2019 inclusive, peaking at 5.56 million ISK (USD M 0.05) per person in 2019, and equating to 78.2% more than their value of 3.12 million ISK (USD M 0.03) per person in 2000.

The third most significant capital asset class was human capital, which represented between 2.5% and 4.3% of the total services value in every year. Apart from the year 2010, when there was a 1.4% reduction, the economic value of human capital services increased year-on-year, reaching its peak of 234,594 million ISK (USD M 1,914) in 2019. This was 129,576 million ISK (USD M 1,057) higher than the value in 2000, equating to an average annual growth rate of 6.5%. In per capita terms, there was a similar trend, with services peaking at 0.657 million ISK (USD M 0.005) per person in 2019. This increased every year apart from 2010, which was the only occasion when the number of graduates in Iceland was less than the previous year's total. Over the whole assessment period, there was a 134.7% increase in the number of graduates in Iceland.

The least significant component comprised of services from built capital, which represented between 0.8% and 1.9% of the total. A general upward trend was evident in the 2000s, with the peak monetary (86,638 million ISK / USD M 707) and percentage value occurring in 2010. Thereafter, following a fall to 34,773 million ISK (USD M 284) in 2011, there was again an upward trend, albeit that the proportion of the total service value ascribed to built capital never exceeded 1.2%. The peak value in 2010 was due to a one-off spike in government expenditure on housing development of 43,204 million ISK (USD M 352), otherwise, annual aggregate data for this component fell consistently within the range of 40-65 million ISK (USD M 0.33 to 0.53).

3.4 Disutility linked to undesirable environmental and social conditions

As a monetary value, except for 2001, environmental and social costs increased year-on-year to a decadal peak of 288,139 million ISK (USD M 2,351) in 2008. In 2009, environmental and social costs declined by 27,929 million ISK (USD M 228), a reduction of 9.7%. This was in excess of the contraction in GDP of 7.9%. After further reductions in 2010, 2011, 2013 and 2014, environmental and social costs increased, reaching an assessment period high of 323,937 million ISK (USD M 2,643) in 2019. In per capita terms, environmental and social costs only exceeded 1.0 million ISK (USD M 0.008) per person in the years from 2006 to 2008 inclusive, and they were below 0.8 million ISK (USD M 0.007) per person from the years 2012 to 2017 inclusive. Average environmental and social costs were 0.93 million ISK (USD M 0.008) per capita in the 2000s, and they reduced by 12.9% to 0.81 million ISK (USD M 0.007) per person in the 2010s.

Environmental and social costs were equal to between 9.5% and 13.0% of the value of Icelandic GDP and constituted a deduction of between 17.8% and 25.4% of HFCE across the assessment period. As a percentage of GDP, environmental and social costs were highest in the period 2000 to 2006. From 2008 to 2017, they declined as a proportion of GDP to the low of 9.5%, before increasing slightly again in 2018 and 2019 to 10.9%. With respect to HFCE, environmental and social costs varied only slightly in the 2000s, peaking at 25.4% of this value in 2002 and 2008, and averaging 24.2% from 2000 to 2009. In the period 2010 to 2019, the highest percentage was 24.1% in 2010 and the average was 20.6%. With respect to both GDP and HFCE, the data thus suggests a slight relative decoupling between expanded economic activity and environmental and social costs.

With respect to their components, the largest share of environmental and social costs belonged to the social costs of economic activity (49.7% to 69.5%), followed by the costs of pollution (29.4% to 49.4%), and then depletion of natural capital (0.1% to 7.7%). The social costs of economic activity experienced a decadal peak in 2009 of 164,684 million ISK, which reduced to 150,481 million ISK (USD M 1,228) in 2012, before increasing again to the overall peak of 225,239 million ISK (USD M 1,838) in 2019. The dominant share of this cost component related to the costs of commuting, which were 145,128 million ISK (USD M 1,184) in 2019, more than double their value at the start of the decade. The other significant component in social costs was unemployment, the value of which peaked in 2009 at 90,332 million ISK (USD M 737).

Costs of pollution were relatively stable across the assessment period, always in the range 88,627 to 107,215 million ISK (USD M 723 to 875). On three occasions they exceeded 100,000 million ISK: in 2007, 2008 and 2009. Greenhouse gas emissions (60.5% to 70.6%) and air pollution (25.2% to 37.0%) were by far the two largest contributors to the costs of pollution. Whereas deaths from air pollution reduced over the assessment period from peaks of 49 persons in 2000 and 2001 to a low of 33 individuals in 2016, and thus costs followed a downwards trajectory. The opposite was generally the case with respect to greenhouse gas emissions. These costs increased steeply from 55,718 million ISK (USD M 455) in 2005 to an assessment period high of 73,343 million ISK (USD M 598) in 2008. Alongside the contraction in the Icelandic economy, they reduced to 64,256 million ISK (USD M 524) in 2012, and thereafter they were no more than 66,850 million ISK (USD M 545). Per capita costs for greenhouse gas emissions were highest in 2008 at 0.23 million ISK per person, however, they reduced gradually and consistently thereafter to the low of 0.19 million ISK per person in 2019.

Depletion of natural capital costs ranged from a low of 1,490 million ISK (USD M 12.16) in 2001 to a high of 22,132 million ISK (USD M 181) in 2009. From 2012 onwards, these never exceeded 6,756 million ISK (USD M 55.12. The figure in 2009 was based on a spike of 20,213 million ISK (USD M 165) in costs in respect of the overharvesting of fisheries, which have been reduced to zero or almost zero from 2015 onwards. Costs relating to the replacement of non-renewable resources were in the range 439 (in 2012) to 655 (in 2018) million ISK (USD M 3.6 to 5.3), however, there were year-on-year increases between 2012 and 2018. Over this period, consumption of fossil fuels increased from 5,394,048 to 8,058,381 barrels of oil equivalent, an expansion of 49.4%.

4. Discussion

4.1 Summary of outcomes and policy relevance

The results of the study provide evidence that economic welfare in Iceland may be far in excess of the value captured by GDP, potentially by as much as multiples of 2.41-3.05 times. These outcomes underscore the significance and scale of non-market benefits that are unaccounted for in GDP. The estimated value for the annual flow of ecosystem services supplied by natural capital was in excess of GDP each year, and social capital was estimated to be in excess of the value of HFCE from 2011 onwards. Nearly all national GPI studies in the academic literature to date differ from the outcome here, estimating that GDP is in excess of the GPI, with the two measures often diverging too. The publication of Kubiszewski et al. (2013) found that although global GDP had increased by more than three times since 1950, the GPI, based on estimates from 1950-2003 for seventeen nations, had decreased after 1978. However, these results and those of recent national estimates, such as those of Kenny et al. (2019) and Patterson et al. (2019), were based on the first iteration of the GPI methodology. This study was undertaken with reference to the GPI 2.0 methodology outlined by Talberth and Weisdorf (2017), an approach that places greater emphasis on the inclusion of monetised welfare benefits from all capital assets, including natural.

The aim of this paper was not to compare its results with the Talberth and Weisdorf (2017) US GPI 2.0 pilot study, since the indicators varied in a few respects, and the economies of Iceland and the US are non-comparable. The US is a highly diversified economy and has a population of around 330 million people. Iceland has an economy focused predominantly on tourism, fisheries and financial services, with a population of 0.1% the size of the US. Some interesting differences were nevertheless evident in the study outcomes. In the US, environmental and social costs aggregated to about 60% of the services from essential capital and over 80% of market-based welfare, whereas for Iceland these numbers were less than 10% and 10-20%, respectively. The issue of renewable energy certainly players a considerable role in the different outcomes in the two studies. In Iceland, 99.9% of electricity generation is from renewable energy (NEA, 2020), whereas this figure was only about 21% in the US in 2020 (Shahan, 2021). In Iceland, around 84% of primary energy is from renewable energy resources, whereas this was only 12% in the US in 2020 (EIA, 2021). The two largest contributors to environmental and social costs in the US study were the replacement costs of non-renewable resources and noise emissions. The former was very small in Iceland due to the harnessing of renewable energy resources and the latter were not assessed due to lack of studies/data on this subject.

Despite the seemingly positive portrayal of macroeconomic progress in Iceland, this does not detract from the fact that the GPI estimates shed light on aspects where the nation could potentially perform better. Environmental and social costs were still non-negligible, amounting to 9.5-13.0% and 17.8-25.4% of GDP and HFCE, respectively, across the assessment period. All other components being equal, the reduction of these costs would lead to a higher GPI value and greater divergence beyond GDP. This study revealed that the most significant economic costs relating to environmental and social aspects of the economy were greenhouse gas emissions, air pollution and fossil fuel consumption. Although it was not the aim of this paper to analyse the interrelationships between cost components, it would appear that the factors of increased household car ownership, population growth and a burgeoning tourism sector not only contributed to expanded GDP, but also imposed related costs. The issues of greenhouse gas emissions, air pollution and fossil fuel consumption have also been reported in academic evaluations of the environmental sustainability of Iceland (Olafsson et al., 2014; Cook et al., 2017), and growth in the tourism sector has been pinpointed as one of the main drivers (Saviolidis et al. 2021).

The highlighting of environmental and social costs on a macro scale represents one of the main contributions of the GPI to informing decision and policy-making. Although the GPI cannot be used to directly determine policy, and neither can GDP, its overall outcome and components facilitate greater awareness of the costs and benefits of economic strategies, including the need for corrective action. Additionally, its calculations can provide ballast in support of existing policies. This is evidently the case with regards to Iceland's Climate Action Plan which is tasked with delivering at least a 29% reduction in greenhouse gas emissions by 2030 compared to a 2005 baseline in accordance with the Effort Sharing Regulation and nationwide carbon neutrality by 2040 (MENR, 2020). The main sources of greenhouse gas emissions in Iceland, excluding land-use, are fossil fuels for cars and ships, industrial processes, and agriculture (MENR, 2020). There is thus a need to switch to alternative, low-carbon fuels for transportation, shipping and fisheries in Iceland (Davíðsdóttir et al., 2017; Helgason et al., 2020; Shafiei et al., 2018).

More broadly, there have also been studies into how the fulfilment of Target 19 of SDG 17 can act as a spur for policy initiatives of benefit to other SDG objectives. The study of Cook and Davíðsdóttir (2021a) found that GPI cost and benefit components could be linked to targets in fourteen of the seventeen SDGs.

4.2 Omitted variables and methodological challenges

Although the GPI is much more comprehensive and nuanced than GDP, and the GPI 2.0 method has sought to establish coherence in terms of factors measured by the GPI and how it is done, no measure of economic welfare is all-encompassing and without pitfalls. Several potentially significant costs and benefits were excluded from this study, mainly due to an absence of data in Iceland or evidence of insignificance, and some important components were by necessity based on proxy measures. It was largely for these reasons that the study differed in a few ways from the pilot GPI 2.0 methodology for the US by Talberth and Weisdorf (2017).

Excluded environmental and social costs commonly included in the GPI 2.0 method are the replacement costs of groundwater depletion; water pollution; noise pollution; and underemployment. Iceland has very abundant freshwater resources and is thus not depleting groundwater reserves (Gunnarsdóttir et al., 2016). With regards to water pollution, the GPI 2.0 method values this issue via willingness to pay (WTP) to clean up an area or restore it to its previous level of water quality (Talberth and Weisdorf, 2017). No such studies have been undertaken in Iceland, which is likely to be due to the very high quality of Iceland’s freshwater resources (Gunnarsdóttir et al., 2016) and the fact that instances of coastal pollution from accidents in sewage processing plants have been very rare. In a similar vein, no studies in Iceland have been undertaken into the economic costs of noise pollution, which, if it exists, is likely be in Reykjavík, where most of the nation’s industrial activities occur. No data was available to estimate the costs of underemployment in Iceland, in particular studies which differentiate between those individuals who choose to work part-time and those who would rather be employed more fully but are prevented due to problems such as lack of available work, no transportation or childcare demands. Due to lack of data, other omitted variables in comparison to the US GPI 2.0 pilot study by Talberth and Weisdorf (2017) included the costs of underemployment, charitable giving, legal services, home improvements and household security purchases. Some sub-components in Talberth and Weisdorf (2017) were also deemed irrelevant to the Icelandic case, for example, the fact that all space heating, hot water and electricity supplied in domestic residences is from renewable energy sources meant that the costs of household pollution abatement were deemed likely to be zero or very low. The value of internet services was excluded because this was thought likely to result in double counting due to its inclusion in HBE.

Perhaps the most significant omission specific to Iceland’s economic welfare concerned the economic costs of soil erosion. No nation in Northern Europe has experienced the level of soil erosion found in Iceland, and it has been estimated that around 50% of the soil and vegetative cover present at the time of Iceland’s settlement (around 874 CE) has been lost (Arnalds and Kimble, 2001). One of the difficulties in Iceland has been determining the extent to which soil erosion can be attributed to economic activities (Sigmundsson et al., 2020). Greipsson (2012) found that soil erosion on heathland in the south of Iceland was influenced by a blend of factors, including natural processes, climate change and land-use management. In addition to lack of knowledge concerning the precise extent of the human contribution via overgrazing, no studies have yet been undertaken in Iceland to estimate the likely economic costs. This led the authors to omit the costs of soil erosion until the results of such studies have become available.

On the issue of the use of proxy data, the most significant component was the estimate of the economic value of Iceland's ecosystem services. This was taken from the work of Cook and Davíðsdóttir (2021b), a study reliant on the benefit transfer method using CORINE land cover data for Iceland (National Land Survey, 2018), together with the latest aggregate ecosystem service values for related biomes in the Ecosystem Services Valuation Database of de Groot et al. (2020). Several cautionary notes need to be made concerning the estimate. Firstly, the reliance on the benefit transfer method due to the lack of WTP studies in an Icelandic context. Secondly, the fact that the estimate is static since a nationwide land cover assessment was first undertaken in Iceland in 2018. Thirdly, the study of Cook and Davíðsdóttir (2021b) excluded estimates of the value of cultural ecosystem services, which may imply that the study's aggregation is an underestimate of the actual scale of the economic value of Iceland's ecosystem services. Fourthly, the paper contended that the study was a starting point in highlighting the economic value of Iceland's ecosystem services, not an end. Therefore, there is a need for primary valuation studies on willingness to pay for the ecosystem services specific to each Iceland biome and specific socio-demographic characteristics.

Other assumptions that are likely to be far less significant were made concerning the calculations of the economic benefits of the volunteering sector in Iceland, which was also derived using benefit transfer; the volume of total waste generation in the years prior to 2014, which was based on the scale relationship between municipal and total waste volumes in the years 2014 to 2019; the use of government expenditure on pollution abatement as a proxy for avoided costs; and applying government expenditures on built capital infrastructure as a proxy value in the absence of information about service flows. In addition, although the study adhered to the approach of Talberth and Weisdorf (2017) concerning the use of relative income inequality to adjust utility from the consumption of goods and services, this is a contentious approach. It could be argued that the level of absolute inequality is of more concern in a society than the extent to which there is deviation from the year of least income inequality.

4.3 Future analysis and dynamics

Further research on the Icelandic GPI, and alternative measures of economic welfare in general, should focus on the interrelationships and trade-offs between components, and scenario analysis whereby benefits can be maximised and costs minimised. As far as the authors are aware, no system dynamics approaches have been developed with respect to the GPI, no doubt in part due to the complexity of the endeavour, although such analysis was called for by Kenny et al. (2019). In this context, more thought should also be given to the underlying philosophies and paradigms that might be best for maximising outcomes from alternatives measures of economic wellbeing, which could include the continuation of a growth-focused mantra, steady state economics, or a degrowth agenda.

A glaring issue that fell outside of the assessment period of this study is the impact of COVID-19, both on GDP and the GPI. The full extent of the economic contraction in Iceland is not yet known, although unemployment rates have been higher than during the last economic recession from 2008 to 2010 (Statistics Iceland, 2020h). This will entail additional costs in the GPI, and HFCE will be reduced, but there are also likely to be increased benefits from contraction. One of the main drivers of greenhouse gas emissions in Iceland has been the demand for rental cars by tourists (Saviolidis et al., 2021). The tourism sector in Iceland ground to a near halt after March 2020. Additionally, and entirely unrelated to COVID-19, there has been a considerable expansion in sales of electric vehicles during 2020. 63% of new vehicles sold in Iceland during September 2020 were electric, all of which will be fuelled by renewable electricity (Kane, 2020). Thus, it is likely that the economic costs of greenhouse gas emissions and commuting will decline considerably in 2020. Due to increased national investment, benefits relating to public healthcare and education services will have increased markedly in 2020 (Statistics Iceland, 2020e).

4.4 Limitations of the GPI

In addition to some of the methodological and data-related challenges involved in the GPI estimation for Iceland, there are some deeper limitations to the measure that have been already explored in the academic literature. These include, but are not limited to:

- Contentions that the GPI is a measure of weak rather than strong sustainability (Hoekstra, 2019).
- Lack of standardisation of methods to enable comparisons between countries (Bagstad et al., 2014; Kubiszweski et al, 2013).
- Use of methods reliant on WTP outcomes from stated preference techniques or the benefit transfer method as a proxy for consumer surplus – these have sometimes far exceeded the outcomes when actual behaviour is evaluated in laboratory settings (Loomis, 2011).
- Lack of consideration of irreversible thresholds and tipping points in relation to certain environmental costs (Neumayer, 2000).
- Omission of embedded environmental impacts, such as the greenhouse gas emissions linked to the transportation of products and resources that are later consumed in Iceland. Due to the island status of the nation, these could be considerable.
- Omission of costs that are shifted abroad or occur in the future (Van der Slycken and Bleys, 2020).
- The difficulties of monetising all benefits received from capital stocks without recourse to focusing on investments and the difficulties of monetisation in the case of benefits from social capital (Hoekstra, 2019).
- Subjective interpretations concerning what constitutes a cost or benefit linked to an economic activity and the scope of the GPI (Lawn, 2003).
- Need for more understanding of interlinkages and trade-offs in the GPI that would reduce the potential for double counting of benefits and costs (Kenny et al., 2019).
- Lack of dynamic analysis of the economic value of Iceland's ecosystem services which would account for the negative feedback of disutilities to natural capital (Cook and Davíðsdóttir, 2021b).

In addition to this list, certain environmental impacts in Iceland can be locally severe but nationally insignificant, such as concentrations of hydrogen sulphide emissions close to geothermal power plants, which can be strong enough to kill (Austigard et al., 2018).

5. Conclusion

Alternative measures of economic welfare have been adopted with increasing frequency around the world in recent years, not least due to their advancement within Target 19 of SDG 17 as a means of providing a more insightful portrayal than GDP concerning the costs and benefits of macroeconomic activities. This study provided the first preliminary estimate of the GPI for Iceland, exploring performance, identifying the main cost and benefit components, and providing a comparison to GDP over the period 2000-2019. Throughout the assessment period, the Icelandic GPI was in excess of GDP, mainly due to its inclusion of non-market benefits from all capital asset classes. The economic value of ecosystem services from natural capital was estimated to be in excess of GDP. Although Iceland's economy is already highly decarbonised, environmental and social costs accounted for within the GPI were non-negligible, mainly relating to greenhouse emissions from transportation and shipping, and the damage effects of air pollutants such as particulate matter.

This study provided a starting point in the cultivation of enhanced understanding concerning Iceland's macroeconomic performance with implications for human well-being. Further knowledge needs to be ascertained with regards to the trade-offs and interrelationships between cost and benefit components in the Icelandic GPI, and methodological advancement needs to take place to understand the implications of land-use change, especially dynamics relating to the costs of soil erosion and the benefits of ecosystem services.

Internationally speaking, the study provides, as far as the authors are aware, the first example of the application of the GPI 2.0 method to assess the economic welfare of a nation. The outcomes reinforce the importance of gaining understanding concerning the economic value of nations' ecosystem services, and the residual environmental and social costs of island states that have already largely transitioned to a renewable energy-based economy.

Acknowledgements
This paper has received no external sources of funding. The main author, David Cook, is in receipt of a Post-Doctoral Fellowship Grant from the University of Iceland.

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