

The Genuine Progress Indicator's development and applications – a systematic literature review from 1995 to 2023

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Abstract

The Genuine Progress Indicator (GPI) is a composite economic indicator designed in 1995 to consider the trade-offs between the costs and benefits of economic activity, seeking to provide a more comprehensive view of macroeconomic wellbeing than is revealed by market activity measured by the Gross Domestic Product (GDP). The measure was developed as a response to the lack of consideration of societal and environmental dimensions in the economic development debate and includes monetary adjustments that reflect effects of economic activity to economic welfare. The study applies the PSALSAR systematic literature review methodology to extract the main themes and discussions related to the GPI, including its methods and policy applications, based on the period 1995 to 2023. The analysis of 43 reviewed publications suggest that the GPI has evolved substantially during the period examined, gaining more solid theoretical foundations, yet there are diverging opinions in the literature on its purpose, methodology, and extent to which it can inform sustainable development. Most of the studies were conducted in developed countries with the purpose of comparing GPI and GDP and highlighting the welfare implications of its different components. Various calls for GPI methodological alignment enabling comparability between studies remain largely unanswered, as the GPI 2.0 methodology has not gained traction. Varying accounting approaches used to compute GPI sub-indicators confirm a persistent lack of convention in valuation methods. The findings suggest ongoing development of the GPI since 1995 but scant evidence of its policy implementation. The lack of a shared vision for the future of the GPI among its practitioners appears to be one of the main obstacles to its further harmonisation and application.

Keywords: Genuine Progress Indicator; economic wellbeing indicators; systematic literature review; essential capital assets; natural capital

1. Introduction

Economic growth measured by market activity and expansion has been depicted as a poor indicator of societal progress (Fioramonti, 2024; Kuznets, 1934; van den Bergh, 2022). The limitations of Gross Domestic Product (GDP) as a measure have been explored extensively in relation to economic welfare, sustainability, and wellbeing (Fitousse et al., 2011; Giannetti et al., 2015; Van den Bergh, 2007). Due to its international standardisation and widespread adoption, GDP has become the main measure of macroeconomic progress since the end of World War II (Fioramonti, 2024; Kubiszewski et al., 2013). While GDP is aimed at measuring the extent of market activity, it does not differentiate between activities that are beneficial or harmful to people and the planet or how wealth is generated and distributed, hence it is not a robust metric of economic wellbeing and was not designed to be one (van den Bergh, 2022; Kuznets, 1934). In the light of these limitations, a movement emerged to find alternative ways of measuring progress, referred to as “beyond GDP” (Kubiszewski et al., 2013; van den Bergh, 2022; WISE, 2024). There is also an increasing recognition of the need for alternative ways of measuring societal progress, as is proposed by the Sustainable Development Goals¹ (SDGs), Wellbeing Economy Alliance (WEAll) and numerous other initiatives (Cook & Davíðsdóttir, 2021a; Costanza et al., 2020; Fioramonti, 2024; Hoekstra, 2019). Like many other wellbeing indicators, the Genuine Progress Indicator (GPI) emerged as an alternative to GDP. Like its predecessor, the Index of Sustainable Economic Welfare (ISEW), GPI is a composite economic wellbeing indicator that attempts to capture the costs and benefits of economic activity within a geographic/political boundary and better reflect its social welfare effects (Clarke, 2007; J. Cobb & Daly, 1989).

Partly as a response to the sustainable development paradigm established by Brundtland (1987) report, Daly & Cobb (1989) addressed some of the most pressing economic, social, and environmental issues of the time from the ecological economics perspective in their book, *For the Common Good*, where the first version of the ISEW was delineated as a measure of sustainable economic wellbeing. The GPI is its successor, delineated by Cobb & Cobb (1994), and Cobb, Halstead, and Rowe (1995), who first used the GPI title² that shifts the focus towards the notion of measuring societal progress rather than sustainability, which can arguably only be measured after the fact (Costanza & Patten, 1995). It was an attempt to develop an economic wellbeing indicator that “*would offer a statement of net benefit*” (Cobb et al., 1995) and it has since evolved in terms of theory, methods, and applications. Generally, the GPI calculation starts with household consumption³, adjusts it for income inequality using an income distribution index (most often Gini) then makes a series of adjustments by either adding or subtracting the monetised valuations of economic activity that either enhance or diminish economic welfare (ibid.).

¹ Namely, SDG 17, Target 19 focused on the development of alternative measurements of progress to complement GDP.

² The updated GPI methodology included an updated method for calculating the cost of long-term environmental damage with higher social cost of carbon; omitting cost of urbanisation and defensive and public expenditures on health and education; and adding five additional variables: value of volunteer work, cost of crime, cost of divorce, cost of underemployment, and gain in leisure time.

³ Usually measured by personal consumption expenditures (PCE) or household budget expenditures (HBE).

The motivation for this study is a response to the need for alternative ways for measuring progress towards sustainable development that go beyond economic growth. There is a drive by various political bodies, including the United Nations (UN) and national governments within WEAll, to identify, develop and adopt alternative measures of economic wellbeing, but there is little consensus on the suitability, methodological robustness, and policy applications of such tools (Hoekstra, 2019). Jansen et al. (2024) analysed 65 such indicators and found that they fall under three main categories: environmental sustainability, different aspects of wellbeing and inclusion, and that only a handful of them address all three. One of them is GPI that emerged as alternative measure of macroeconomic welfare three decades ago and has developed substantially since then, yet its place in the wellbeing economics literature and use in policy making remains understudied.

To our knowledge, this is the first systematic literature review exploring GPI methodological developments in this timescale. Summarising the key contributions of GPI to the “Beyond GDP” literature, its methods, and implications to policy has a potential to clarify the role of this indicator in measuring sustainable economic welfare to date and in the future. For this purpose, the review aims to map out the body of literature on GPI since its inception in 1995 up to 2023, focussing on location, scale, time periods covered, methodological approaches, and policy applications. The study aims to answer the following research questions:

1. What has been the geographical distribution and scale of GPI studies, main publication outlets, and motivations for conducting?
2. What have been the key methodological developments and approaches in the GPI since 1995?
3. What are the issues and policy implications of the GPI discussed in the literature?

Answering these questions may help to address the issues identified and discern the role of GPI in the “beyond GDP” literature. The structure of the paper is as follows: Section 2 presents a step-by-step methodology of the literature review. Section 3 presents the results of the review together with discussion. Section 4 discusses the future research avenues, study limitations, and concludes the paper with a short summary of findings and some reflections on the potential future of the GPI.

2. Methodology

2.1 PSALSAR methodology for systematic literature review

To fulfil the purpose of the review to delineate the recent developments of the GPI, a meta-analysis method combining the Search-Appraisal-Synthesis-Analysis (SALSA) (Grant & Booth, 2009; Malinauskaite et al., 2019) and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodologies called PSALSAR was utilised. PSALSAR was designed to facilitate a reproducible systematic review while also allowing for inclusion of some quantitative elements, and it has been successfully applied in sustainability research to perform a thematic analysis, and for this reason was selected for this study (Kamali Saraji & Streimikiene, 2023; Merida et al., 2022). This study adhered to the methodological approach of (Mengist et

al., 2020). Table 1 lists the main steps of the method, together with explanations of each stage, and each step is elaborated further in the next section.

Table 1. Components of a systematic literature review following PSALSAR methodology.

Step	Task	Explanation
Research protocol	Define study scope	Defining the research aims, scope, methods, and databases to be used
Search	Search for publications relevant to the study aims	Searching in Scopus and Web of Science using specific keywords and Boolean strings
Appraisal	Select eligible studies	Applying the selected criteria to include or exclude studies from the review
Synthesis	Classify and systemise information extracted from the included studies	Reading the selected publications in full, systemising information according to selected categories in line with research aims, adding publications through snowballing method, extracting the principal themes
Analysis	Analyse the systemised information	Analysing the systemised information, contextualising
Report	Summarising the results of the analyses in a form of a scientific article	Writing up the review in accordance with the standards of a peer reviewed-academic journal

2.2 Step-by-step methodology

Step 1. Research protocol. The main aim of this step is to specify the scope of the research by formulating the research questions and defining the strategies to answer them (Booth et al., 2021; Kamali Saraji & Streimikiene, 2023). It is not a purpose of this study to provide an exhaustive review listing every publication linked to the GPI or its predecessor, the ISEW, but rather to review a set of scientific studies published in peer-reviewed academic journals, focussing on nation states and large sub-national entities, e.g., regions and large cities.

Step 2. Search. This step entails developing and implementing a search strategy. For the purposes of this study, two of the most used academic search databases, Scopus and Web of Science, were utilised to source relevant publications using the following Boolean strings: Scopus: TITLE-ABS-KEY ((“genuine progress indicator”) OR (“genuine progress indicator” AND “methods” AND/OR “development”)); Web of Science: All= ((genuine progress indicator) OR (genuine progress indicator AND methods AND/OR development)). These search strings produced a substantial number of studies (109 results on Scopus and 133 studies on Web of Science), and no additional Boolean strings were used.

Step 3. Appraisal. The papers sourced through the academic search engines were then evaluated according to the research aims, applying the following criteria:

- the search keywords “genuine progress indicator” are in the paper title, abstract or/and keywords;
- published between 1995 and the date of the search (2023) in the English language;
- published in academic peer-reviewed outlet;
- presents a primary GPI study, excluding reviews and purely theoretical discussions;
- addresses GPI methods and/or their practical applications in some depth;
- full text of the paper is available online;
- duplicates were removed, even if published in different outlets with slight modifications.

As Figure 1 indicates, from the 242 papers sourced, 179 were excluded after reading the abstracts as they did not fulfil the criteria above, 15 more were excluded after reading the full papers because they either referred to the same empirical study more than once within different studies, or were not primary but meta-studies, and for seven papers no full text was available online.

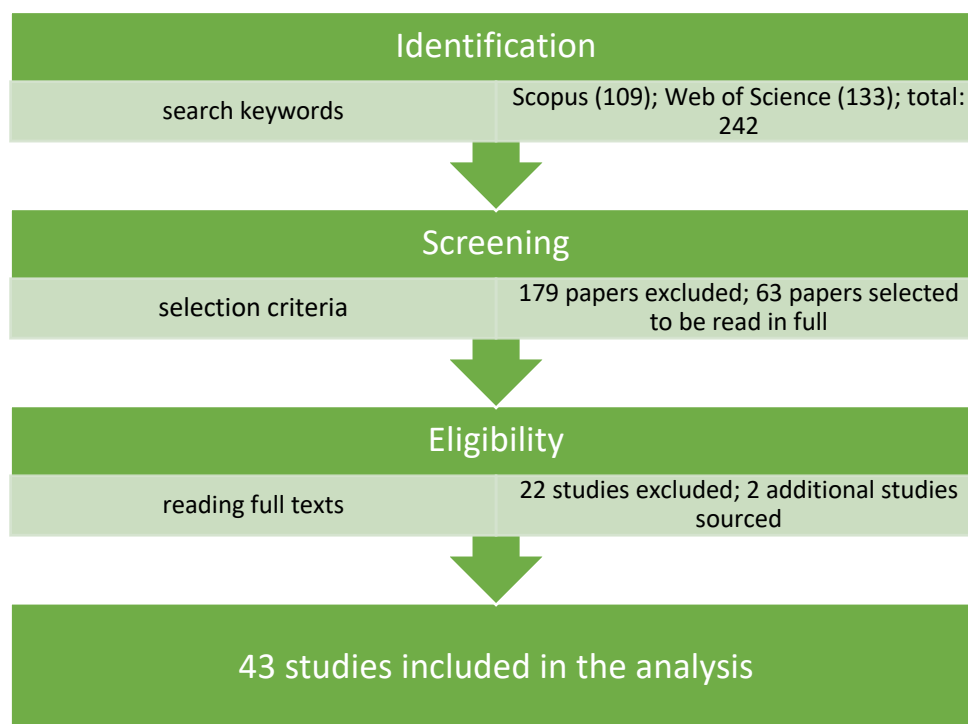


Figure 1. Research information flow for identification of GPI studies.

Step 4. Synthesis. The 41 papers fulfilling the selection criteria and available online were read in full, and two additional publications were sourced using “snowball” method (Kamali Saraji & Streimikiene, 2023; Malinauskaite et al., 2019). The extracted information was classified into general and specific categories: general included publication year and outlet, study location, years covered, scale, reasons for conducting, the number of indicators, and specific – methodological innovations, policy insights, and suggestions for the future development of GPI. The main findings in each category are listed in Appendix A.

Step 5. Analysis. This stage included analysis and discussion of the systemised information, connecting, and cross-referencing between the studies and themes, and contextualising the findings within the literature. The results of the analysis are presented in the following section, where results are presented together with discussion.

Step 6. Reporting. This final step of the systematic literature review involved organisation and presentation of the critical points resulting from the previous two steps and presenting them in the format of an academic paper.

3. Results and discussion

In this section, the main themes identified during the systematic review are presented together with discussion to put them into context. Firstly, the general results are presented and discussed: overview of GPI studies' motivation, date, location, scale, and common data sources used. Secondly, the discussion on the theoretical foundations of GPI in the literature are outlined. Then, the numbers of sub-indicators, their correspondence to the essential capital assets framework, and most widely used accounting methods are presented, with a discussion of the usefulness of the GPI as an indicator of macroeconomic welfare. Detailed results of the analysis are provided in Appendix A.

3.1 General information and trends

The common stated motivations for conducting GPI studies vary and include: (i) highlighting the costs and benefits of economic growth, (ii) attempting to measure sustainable development, (iii) estimating the level and growth of economic wellbeing and comparing it to the level and economic growth measure by GDP, (iv) informing policy, (v) applying several sustainability/wellbeing indicators and comparing/combining results for a fuller view on societal progress, (vi) updating and improving the GPI methodology, and (vii) highlighting disparity in progress between different populations.

The studies were conducted between 1995 and 2023, with two of them published in 2024 but already appearing within academic search engines at the end of 2023. Out of the 43 studies, 3 were published between 1995 and 2004, 15 between 2005 and 2014, and the remaining 25 – between 2015 and 2024. From the early 2000s, GPI studies increasingly focussed on sub-national scales, especially in the United States, starting with the studies by Costanza et al. (2004) in the State of Vermont, U.S. and Clarke & Lawn (2005) in the State of Victoria, Australia. Out of the 43 studies included in the analysis, 18 were focussed on nation states, 15 on sub-national entities, such as states, provinces, and cities, 7 included both scales, and 3 addressed the multinational scale. In terms of outlets, by far most of the studies were published in the *Journal of Ecological Economics* (19), followed by *Journals of Social Indicators Research* (5) and *Ecological Indicators* (4). The remaining 15 publications were published in various outlets, all focussed on sustainability and/or economics.

As is shown in Figure 2, the bulk of studies examine economic wellbeing in developed countries. GPI studies were conducted in 41 countries and the populated six continents, but only seven of them addressed low- and middle-income countries as classified by the World Population Review (2024): Brazil, China, India, Madagascar, Malaysia, Thailand, and Ukraine. A large proportion of studies focussed on national and sub-national applications in the US (10), China (8), nations within the European Economic Area (7), followed by Australia (4), Japan (3), and New Zealand (2).

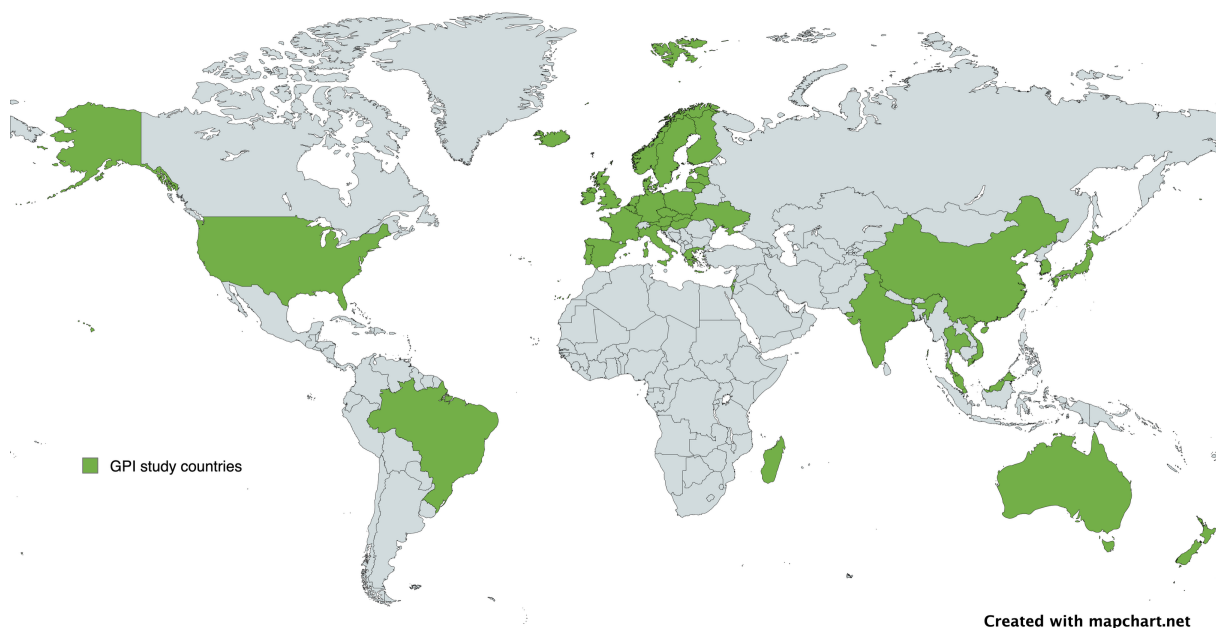


Figure 2. GPI study location countries from the review.

These trends suggest growing interest in the GPI topic, which might be due to the increasing recognition in academia and global policy initiatives for sustainable development and prosperity that alternative ways of measuring economic wellbeing are needed. It is also likely that in the beginning of the period examined, the GPI and ISEW were used simultaneously, and only later did the former take precedence. The findings also suggest that measurement of economic welfare is still mostly a pre-occupation of high-income societies⁴ that have reached a level of economic development where economic growth and wellbeing might be starting to diverge (Lawn & Clarke, 2010). They also imply a need to address the wellbeing implications of economic growth early in the development path to avoid unsustainable development strategies (Cook & Davíðsdóttir, 2021a).

Most of the studies (41) include comparisons between GPI and GDP outcomes, and by far the majority of them (38) reported GPI values to be consistently smaller than GDP, with a varying but usually lower growth rate. The one study reporting GPI values much larger than those of GDP was by Cook & Davíðsdóttir (2021), and this is mostly due to the inclusion of an estimated value for Iceland's terrestrial ecosystem services (ES) using the benefit transfer method and the GPI 2.0 methodology (Cook & Davíðsdóttir, 2022). This approach contrasts with the tendency in other GPI studies not to include ES benefits and only account for the economic value of specific natural capital losses. The other two papers by Lazarus & Brown (2022) and Van der Slycken & Bleys (2024) report GPI values larger than GDP, both resulting from methodological innovations: the former by removing historical benchmarks from the calculations, and the latter by designing two distinct methodologies, where one considers the environmental costs of economic activity in other parts of the world and future generations, and the other only considers costs experienced at the present time within country borders. The rest of the studies demonstrate very high variability in GDP/GPI results and growth rates (see Appendix A). The

⁴ With the exception of China where the number of GPI studies start increasing in 2010s, in parallel with country's rapid economic development.

common trend is that the GPI starts at a lower or similar level as GDP and grows in parallel until some point, usually occurring between 1960-1990, and after that threshold starts to diverge, widening the gap between the values per capita as well as on a growth rate basis.

Similar trends, observed by numerous GPI practitioners, have been linked to the “threshold hypothesis” of Max-Neef (1995), which suggests that at a certain level of economic growth, it may become „uneconomic“ when the marginal costs of economic activity start exceeding the benefits: *“for every society there seems to be a period in which economic growth (as conventionally measured) brings about an improvement in the quality of life, but only up to a point – the threshold point – beyond which, if there is more economic growth, quality of life may begin to deteriorate ”* (Max-Neef, 1995, p. 117). While the hypothesis has neither been confirmed nor denied, some evidence based on GPI results are presented by Lawn & Clarke (2010) and Long & Ji (2019) among the studies included in the review, and a meta-analysis of GPI studies in 17 countries that generated 59% of the world’s GDP in 2005 by Kubiszewski et al. (2013). It found that between 1950 and 2005, GDP and GPI were following a similar trend up to around US\$7,000 GDP per capita, diverging after that, which may be indicative of the rising costs of economic growth (Berik, 2020). However, in their critique of the GPI, Dietz & Neumayer (2006) suggest that the threshold effect is more likely to result from methodological flaws rather than any true reflection of social welfare effects of economic growth.

The most commonly used data sources for the GPI calculation (see more details in Appendix A) include national statistics offices, governmental departments and agencies, international organisations, such as the UN, the World Bank (WB), the Organisation for Economic Cooperation and Development (OECD); in the European context, the European Union (EU) and its statistical agency EUROSTAT, European Environment Agency (EEA), and the annual macro-economic database of the European Commission (AMECO); in the U.S., the Bureaus of Economic Analysis and Labour Statistics, Environmental Protection Agency (EPA), the Energy Information Administration (EIA), the American Time Use Survey (ATUS) and various state departments and agencies; in China, the national and regional statistical yearbooks and the Institute of Geographic Sciences and Natural Resources were most commonly used. Most studies examined in the review relied on estimates from previous studies, e.g., a benefit transfer method for calculation of the economic benefits from ES using the Costanza et al. (1997) global valuation study or The Economics of Ecosystems and Biodiversity Database (TEEB) valuation database (Van der Ploeg et al., 2010). Lack of data that necessitates use of proxies and “heroic assumptions” is quoted repeatedly as one of the main obstacles to the development and widespread adoption of the GPI (J. Cobb & Daly, 1989; Cook & Davíðsdóttir, 2021a; P. Lawn, 2005).

3.2 Theoretical foundations

The theoretical foundations of the GPI explain some of its methodological inconsistencies. One of the creators of the System of National Accounts used to calculate GDP, Simon Kuznets, inferred that *“the abuses of national income estimates arise largely from a failure to take into account the precise definition of income and the methods of its evaluation”* (Kuznets, 1934, p. 6). This points to the importance of setting clear theoretical foundations, underlying assumptions, and a definition of what a welfare index is designed to measure. In the case of the GPI, this has not been universally agreed, as sub-indicators measuring present economic welfare

and externalities are combined with estimates of past or future losses of essential capital. The theoretical foundations of the GPI are subject to debate in many of the selected studies (Bagstad & Shammin, 2012; Makino, 2008; Nourry, 2008; Talberth et al., 2007; Talberth & Weisdorf, 2017; Van der Slycken & Bleys, 2023) and the wider literature (Clarke, 2007; Dietz & Neumayer, 2006; Kubiszewski et al., 2013; P. Lawn, 2003, 2005; Neumayer, 1999; Talberth et al., 2007).

Daly & Cobb (1989) based their first iteration of the ISEW on Hicks' (1946) notion of income⁵, but the index was criticised for attempting to measure both current economic wellbeing and sustainability, which was compared by its critics to merging different measurements of an automobile dashboard into one, lacking scientific rigour and logic (Dietz & Neumayer, 2006; Neumayer, 1999). To solidify the GPI's theoretical basis, Lawn (2003, p. 106) suggested that it should measure the *"welfare a nation enjoys at a particular point in time given the impact of past and present activities"*. Given the complexities in measuring these impacts, there is an emerging consensus that the GPI is better conceived as a measure of "psychic income", a concept stemming from the Fisher's (1906) notion of income⁶. This definition implies that the GPI is rather a measure of socio-economic welfare and progress than sustainability, as it does not account for changes in the essential capital stocks, e.g., it does not place a monetary value on stocks of natural, social, built or human capital but does for the flow of some services from them. In accordance with this understanding and for the purposes of the GPI 2.0 method, Talberth and Weisdorf (2017, p. 3) define it as *"a monetary measure of economic welfare for a given population in a given year that accounts for benefit and costs experienced by that population in association with investment, production, trade, and consumption of goods and services"*.

Adopting the Fisherian concept of income somewhat clarifies the purpose of the GPI and what it attempts to measure – the flow of benefits and costs of economic activity resulting in economic welfare (or lack thereof) in a certain society in a given time period. It remains unclear, however, how the GPI relates to the sustainability of progress over time and preservation of natural capital, which forms the basis of economic wellbeing in the "economy in society in nature" view (Daly & Farley, 2011; Raworth, 2017; Røpke, 2004). Kubiszewski et al. (2015) and Van der Slycken & Bleys (2023, 2024) offer partial solutions to this problem: the former in a form of a GPI balance sheet listing capital asset stocks and liabilities (also see (Anielski, 2001)), and the latter in considering spill-over costs across time and space boundaries. There have also been suggestions to complement the GPI with System of Environmental Economic Accounting (SEEA) type accounts, that seek to measure stocks and flows of natural capital in both bio-physical and monetary terms (Kenny et al., 2019; UN, 2012).

3.3 GPI sub-indicators and accounting methods

⁵ Hicksian concept of sustainable income originates in the work by John Hicks (1946), who defined income as the maximum amount that can be produced and consumed without depleting the stock of welfare or income generating capital. In a similar manner, Daly's & Cobb's (1989) ISEW aimed to measure societal economic welfare by considering the ability to maintain economic welfare on at least the same level in the future.

⁶ Fisherian concept of "psychic income" uses the definition by Irving Fischer (1906) of economic benefits experienced by consumers rather than the amount of goods and services produced and marketed, as measured by GDP, or the Hicksian notion of income that necessitates non-diminishing stocks of capital.

This study was unable to outline linear trends and methodological developments of GPI over time, as no such trends and developments were identified in the analysis. The selection of sub-indicators and methods rather depended on which previous GPI studies were used as blueprints. According to publishing years and the similarities in methodological approaches, the GPI literature examined in this review can be grouped into three main periods:

(i) the early period from 1995 to early 2000s, starting with the Hanley (1999) and Hamilton (1999) studies for Scotland and Australia, respectively, and characterised by continuous development of the GPI method, discussions on theoretical foundations, and application in different parts of the world, e.g., Australia, New Zealand and the Pacific Asia;

(ii) the middle period, from early 2000s and up to mid 2010s, starting with the Costanza et al. (2004) study for Vermont which was followed by a series of US state-based studies (Bagstad & Shammin, 2012; Fox & Erickson, 2018; Kubiszewski et al., 2015; Posner & Costanza, 2011) and a tendency for solidifying the methodological approach in this context that was taken up by some studies elsewhere (Clarke & Lawn, 2008; Hayashi, 2015) but had not become standardised, partly due to local data limitations and lack of agreement on methodological approaches; and

(iii) the late period from 2017 to the present time that started with the Talberth & Weisdorf (2017) GPI 2.0 study and is marked by further divergence in methodologies despite the attempts to standardise. Therefore, some common methodological approaches and debates are outlined in this section but do not constitute consistent developments over time.

3.3.1 Number of sub-indicators and links to essential capital framework

To provide a more holistic view of societal progress than GDP, the GPI includes corrections in the social, economic, and environmental domains of an economy through use of various sub-indicators. The number of sub-indicators range between 10 and 52, with the majority of studies including between 20 and 26. The stated reasons for the fewest (10-12) components was lack of data (Danilishin & Veklich, 2010; Kusago, 2007; Makino, 2008; Ollivier & Giraud, 2010; Pais et al., 2019), while the biggest range in GPI components (28-52) was observed in the four GPI 2.0 studies (Cook & Davíðsdóttir, 2021b; Guan et al., 2024; Senna & Serra, 2021; Talberth & Weisdorf, 2017).

An aspect brought forth in GPI methodology development is the dependency of economic wellbeing on essential capital stocks, as highlighted by Kubiszewski et al. (2015), Talberth & Weisdorf (2017), Fox & Erickson (2018), Kenny et al. (2019), and Cook & Davíðsdóttir (2021b). The classification of capital assets⁷ used in these studies include natural (KN), built and financial (KB), human (KH), and social capital (KS). Financial capital is not itself productive and refers to a system of ownership and control of capital and is therefore rather a vehicle of exchange than

⁷ The four types of essential capital assets are defined by Goodwin (2003, p. 1): “*Natural capital is made up of the resources and ecosystem services of the natural world. Produced capital consists of physical assets generated by applying human productive activities to natural capital and capable of providing a flow of goods or services. Human capital refers to the productive capacities of an individual, both inherited and acquired through education and training. Social capital [...] consists of a stock of trust, mutual understanding, shared values and socially held knowledge.*”

essential form of capital. As such, it is grouped here together with built capital, following the approach by Talberth & Weisdorf (2017) and Cook et al. (2022).

Types of essential capital have been discussed in the GPI literature increasingly more often since 1995 literature (Costanza et al., 2004; Hamilton, 1999; Kubiszewski et al., 2015; Talberth et al., 2007), connecting GPI components to essential forms of capital and their respective contributions to economic wellbeing. The numbers of GPI indicators in each group of capital assets in all the studies are listed in Appendix A. Closer examination did not reveal any persistent trends other than that the number of KH sub-indicators included in GPI studies grew slightly over the time period examined as studies included increasingly more human capital dimensions, such as education, healthcare, and commuting, though the overall share of KH sub-indicators remained relatively small at around 8%. It is common in the studies reviewed to omit indicators when data availability is deemed insufficient or components are no longer relevant, e.g., the ozone layer depletion problem is considered by some GPI practitioners to be largely solved, or if they result in double-counting, e.g., internet services that are included in consumption expenditure (see Appendix A for such omissions).

Most of the studies examined in the review group GPI components into economic, social, and environmental categories that correspond to the pillars of sustainability delineated in the Brundtland Report (1987). Such grouping brings forth the dependence of human wellbeing on the four types of essential capital: its natural systems (KN); social structures and connections (KS), people, their skills and capabilities (KH); and built and financial structures that facilitate economic activity (KB). This helps to systemise GPI components and structure in a way that is helpful for analysis of its implications to societal progress.

3.3.2 GPI sub-indicators and methodological approaches

With some variations over time, the general GPI calculation formula from Cook & Davíðsdóttir (2021b) based on Talberth & Weisdorf (2017) is as follows:

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

Where $U_i((HBE_1 - DEFR - HI_i) \times INQ + PP)_i$ represents is the utility from consumption of goods and services, $U_i(s(KH_i + KS_i + KB_i + KN_i))$ refers to utility sourced from essential capital, and $dU_i(DKN_1 + POL_i + SC_i)$ is disutility linked to undesirable environmental and social conditions, and the sub-categories are as follows:

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

The list of GPI components became somewhat solidified in the 2000s, especially in the US context in the attempts to standardise the metric (Posner & Costanza, 2011; Talberth et al., 2007). Table 2 lists the most widely used components of KB, KS, and KH, and KN sub-indicators are specifically outlined in Table 3 alongside an exploration of valuation methods employed, as they were the most numerous and heterogeneous compared to other types of essential capital. + and - refer to addition and subtraction of the sub-indicator values, respectively. The methods for accounting for different indicators vary between studies, and the main methodological innovations stated in the studies are listed in Appendix A.

Table 2. The most common sub-indicators of the four types of essential capital.

Type of capital	Built & financial (KB)	Social (KS)	Human (KH)	Natural (KN)
Most common indicators	+Personal consumption -Income distribution +Services from consumer durables -Costs of consumer durables +Services from highways and streets +/-Net capital investment +/-Net foreign debt	+Value of household work +Value of volunteer work -Cost of crime -Cost of family changes +/-Value/loss of leisure time -Costs of un- and under-employment -Costs of car accidents +Internet services	+Value of higher education -Costs of commuting +Value of publicly provided healthcare +Research and development (R&D) -Welfare- neutral goods	See Table 3

The components in KB have remained somewhat stable in GPI calculations since 1995, except for net capital investment and net foreign debt that are argued to not be in line with the Fisherian concept of psychic income and therefore excluded (Cook & Davíðsdóttir, 2021; Patterson et al., 2019; Talberth & Weisdorf, 2017). There have also been inconsistencies concerning inclusion of different types of built capital as in some studies it is omitted (Karatopouzis et al., 2022; Wen, 2007), in others calculated as government expenditure on streets and highways (Talberth et al., 2007), and in some – as 75% of all government expenditure on built infrastructure (Clarke & Lawn, 2005; Delang, 2016). In other cases, the value of water and energy infrastructure, value of housing development, manufacturing, and construction are used to account for services from KB (Cook & Davíðsdóttir, 2021; Talberth & Weisdorf, 2017).

In terms of the most common KS sub-indicators listed in Table 2, the methods vary between studies. For example, some studies account for leisure time as a positive value (Karatopouzis et al., 2022; Nourry, 2008; Talberth & Weisdorf, 2017; Wen et al., 2007), while others – as a cost of leisure time lost (Costanza et al., 2004; Guan et al., 2021; Kenny et al., 2019). Varying rates are used to calculate its value, e.g., average hourly wage, and can have significant effects on overall GPI results, as demonstrated by Karatopouzis et al. (2022) where a higher rate for leisure time resulted in a larger GPI, which exceeded GDP during one period of the COVID-19 pandemic in Australia. Benefits from household work are also estimated using differing rates, e.g.,

hourly rate of domestic labour or average wage, which affects the significance of this non-market activity in GPI calculations (Brown & Lazarus, 2018). Costs of family changes are omitted in some studies on the grounds that they are not always welfare-reducing (Ostergaard-Klem & Oleson, 2014; Brown & Lazarus, 2018). Internet services are included in GPI calculations by Talberth & Weisdorf (2017) but excluded by Cook & Davíðsdóttir (2021) on the grounds that it would constitute double counting of consumption.

The contributions of KH to economic wellbeing are inherent to it as one of the building blocks of the economy (Kubiszewski et al., 2015). The value of higher education and the cost of commuting have been the most common KH indicators, yet the former has been argued to constitute double-counting and already included in some personal consumption expenditures (Posner & Costanza, 2011). In several studies, education and health expenditures are considered as partly defensive rather than entirely benefits (Andrade & Garcia, 2015; Long & Ji, 2019; Nourry, 2008). Costs of commuting, calculated as the value of time spent commuting plus the costs of transportation, is a commonly used KH indicator. Welfare-neutral goods, such as alcohol, tobacco, and narcotics, constitute another KH indicator that is subtracted from personal consumption (Cook & Davíðsdóttir, 2021).

3.3.3 GPI 2.0

The diverging GPI methodologies and calls for a unified approach (Bagstad et al., 2014; Feeny et al., 2013) galvanised development of the GPI 2.0 methodology. It was delineated by Talberth & Weisdorf (2017) with refined theoretical basis and an expanded range of sub-indicators and linking them to essential capital assets. GPI 2.0 aims to overcome the methodological divergencies of the GPI 1.0 by redefining its purpose as a measure of current experiential (Fisherian notion of psychic income) economic welfare (rather than sustainability over time) generated by final consumption of marketed and non-marketed goods and services causally related to economic activity and monetised using peer-reviewed methods, consistent valuation rules, and the best available data.

The Talberth & Weisdorf (2017) iteration of GPI 2.0 has twice as many indicators as other US-based studies, e.g., Costanza et al. (2004), Talberth et al. (2007), Bagstad & Shammin (2012) which all had 26 sub-indicators. The contributions of KH to economic wellbeing are explicitly stated in GPI 2.0 to which value of green and manufacturing jobs were added (Talberth & Weisdorf, 2017; Senna & Serra, 2021). The items of food and energy waste and household security are added to DEFR in GPI 2.0; charitable giving item – to household investments; internet services – to KS; and services provided by protected natural capital – to KN items. This expansion of items included GPI 2.0 calculations presents a potential for a more comprehensive approach but also increases the likelihood of more items being omitted due to lack of data, especially in non-US contexts. E.g., Cook & Davíðsdóttir (2021b) and Senna & Serra, (2021) included 38 and 35 sub-indicators out of 52, respectively, due to lack of data and irrelevance of some items in their respective context of Iceland and Brazil. Perhaps this is one of the reasons why despite the extensive discussions concerning the GPI 2.0 methodology, this new version has not gained traction since 2017 and was used only in four studies in this review (Cook & Davíðsdóttir, 2021b; Guan et al., 2024; Senna & Serra, 2021; Talberth & Weisdorf, 2017).

3.3.4 Accounting for natural capital components

As KN components are the most numerous and most diverse methodologically, they are discussed separately here. The methods used to estimate their values can be grouped into environmental damage costs (DC) from economic activity that reduce human wellbeing, defensive and regrettable expenditures (DEFR), lost or received ES from KN (ES), and resource depletion costs (RDC), e.g., that of non-renewable resources (NRR) and fisheries. Even though it was established in the theoretical discussion that the GPI is not an indicator of sustainability but rather macroeconomic welfare in a given time period, consideration of services from KN determine the importance assigned to ecological components within the GPI (Posner & Costanza, 2011). In the absence of a standardised set of sub-indicators and valuation methods, different studies often add or omit GPI components in response to local realities, data availability, or subjective interpretations of the most important factors in economic wellbeing (see Appendix A for more details). Even Daly & Cobb (1989), in their first calculation of the ISEW did a version of the index that excluded the depletion of non-renewable resources and net change in wetlands and farmlands due to the associated uncertainties, which illustrates the difficulty of accounting for these services. Table 3 lists the most common environmental indicators used in the GPI studies examined, together with the typical valuation methods used.

Table 3. The main natural capital components used in GPI studies and common accounting methods.

Natural capital sub-indicator	Common accounting methods	Type
-Costs of water pollution	Damage to water quality, pollution abatement costs	DC
-Costs of air pollution	Environmental damage, healthcare, mortality, and/or abatement costs	DC
-Costs of noise pollution	Damage to auditory environment, usually since benchmark year	DC
+/-Costs of net change in wetlands	Net value of wetland ES change since benchmark year, discounted present value of future ES	ES
+/-Costs of net change in farmland	Net value of agricultural production/ES since benchmark year or discounted present value of future ES	ES
+/-Costs net change in forest cover	Net value of forest ES since benchmark year or discounted present value of future ES	ES
-Depletion of non-renewable (energy) resources	Replacement cost by renewable resources (user or producer), resource rent cost	RDC
-Costs of climate change	Social cost of carbon, cumulative cost of carbon since benchmark year, carbon/fuel tax	DC
-Costs of ozone depletion	Long-term damage, health costs	DC
-Costs of solid waste	Clean-up and external costs, municipal waste management costs	DEFR
-Costs of soil degradation	Value of lost ES from benchmark year, or discounted present value of future ES	ES
+Services from (protected) natural capital	Value of ES provided, often via benefit transfer	ES
+/-Costs of land conversion	Trade-off cost via present value of future ES forgone	ES
-Costs of fisheries' depletion	Replacement cost, cost of catch	RDC
Costs of nuclear energy	Costs of nuclear damage, risks, and waste	DC
-Climate costs of aviation and shipping	Carbon damage costs from fuels used	DC
-Costs of extreme weather events	Uninsured losses from natural catastrophes	DC
-Nitrogen pollution	Ecosystem, health, and climate costs	DC
-Costs of food and energy waste	Subtracted from HBE as defensive and regrettable expenditures	DEFR
-Costs of pollution abatement	Subtracted from HBE	DEFR
+Avoided damages from pollution	Government expenditure on pollution abatement	DEFR
+Avoided depletion of ecosystems	Government expenditure on nature protection	DEFR

Accounting approaches for KN components differ between the studies, and some of these methods have different ways of classifying and accounting for similar items, e.g., changes in land-use and changes in wetland, farmland, and forest areas are essentially all concerned with lost ES, but are either estimated as ES lost compared to a certain historical benchmark, e.g., pre-colonial times in the US (Posner & Costanza, 2011; Talberth et al., 2007), or ES not provided due to land use changes with a future discount rate applied (Lazarus & Brown, 2022; Van der Slycken & Bleys, 2023). Talberth and Weisdorf (2017) distinguish between willingness to pay (WTP) and willingness to accept (WTA) in the valuation of KN components, arguing that the former reflects the more direct connection to current economic welfare. Following this logic, the damage cost approach was applied in most studies examined in this review to account for costs of environmental degradation, demonstrative of a less optimal approach that is not based on WTP and therefore does not represent a measure of consumer surplus.

Lazarus & Brown (2022) calculate two variants of the GPI, omitting the historical benchmarks from which ES losses are calculated due to the arbitrary nature of this choice and doubts about whether historical benchmarks are realistic or desirable, e.g., whether it possible to imagine the landscape of pre-colonial times and would returning to a similar situation be beneficial to society. They suggest removing the benchmarks in favour of calculating the costs of lost ES from wetlands, forests, and farmland by multiplying the net change in land area by the present value of future ES that would likely be provided by that area over the next 50 years with a 3% discount rate. Talberth & Weisdorf (2017) take a similar approach when estimating the foregone costs of land conversion. The obvious contention here is that future provision of ES does not fully correspond with the Fisherian concept of income that is only concerned with current (not future) economic welfare.

Another subject for debate has been which services from KN should be included in the GPI. Talberth and Weisdorf (2017, p. 8) suggests only including ecosystem services from protected KN as services provided by unprotected ecosystems *“exist despite, and not because of economic activity and are thus precluded by the GPI's definitional restrictions”*, and that including ES for which monetary value estimations exists, e.g., provisioning and services, may result in double-counting, as many of those ES are already included in consumption expenditure. Cook & Davíðsdóttir (2021b) include value estimation from terrestrial ES in Iceland, resulting in GPI values between 2.41 and 3.05 times higher than GDP and making the results difficult to compare to other GPI studies. Then there is the difficulty of accounting for interregional flows of non-marketed services from KN that cross country borders (Hamilton, 1999) and propositions to account for ES stocks and flows via dynamic spatial modelling, albeit that would mean that the GPI would have to be broadened to account for welfare generated outside the national economy under study (Bagstad et al., 2013, 2014).

Another disagreement related to KN has been linked to whether cumulative damage of environmental effects, such as long-term damage from greenhouse gas (GHG) emissions, pollution, and depletion of wetlands, forests, and farmlands should be incorporated. Kubiszewski et al. (2015) argue that is one of the most straightforward ways of accounting for the current welfare damages of having inherited diminished KN stocks. Talberth & Weisdorf (2017) contend that the present and future losses of KN services are what should be calculated and not past, especially given the arbitrary benchmarks from which cumulative losses are calculated (Lazarus

& Brown, 2022), thus violating their own proposition that the GPI is a measure of current economic welfare.

GPI practitioners do not seem to have a consensus on accounting for NRR depletion, either. Calculation of NRR depletion using El Serafy's (1989) user cost (consumption-based) approach has been most widely applied in the studies reviewed, even though some authors suggest that a resource rent (production-based) approach would be more appropriate as it reflects the loss of wealth due to extraction of NRR within a country's borders, as opposed to resources consumed regardless of their origin (Dietz & Neumayer, 2006; P. Lawn, 2005). A similar argument can be made for more nuanced estimation of the costs of climate change as carbon emissions within political/geographical borders are rarely proportional to the costs of climate change within them, which might be better estimated using regionally specific cost data (Bagstad et al., 2014). Moreover, since the theoretical reconsideration of the GPI's purpose as a measure of current economic welfare and not sustainability of an economy over time, inclusion of the costs of NRR depletion is subject to scrutiny as it arguably does not reflect current economic welfare as it includes drawdowns on stocks that were caused in the past but will contribute to the experience of global damages in the future (Talberth & Weisdorf, 2017).

3.4 Policy uses and implications

The GPI has been suggested as a measure of societal progress and a viable complement to GDP (Cobb et al., 1995), yet little has happened since its inception in 1995 in terms of mainstreaming it into policy. The literature to date has focussed on refinement of methods, sourcing available data, and offering policy suggestions based on GPI results (Hashim et al., 2019; Li et al., 2022; Senna & Serra, 2021), yet there is little evidence of their practical implementation. The GPI is included in the official statistics of the US states of Maryland (State of Maryland, 2024), Utah (Berik & Gaddis, 2011), and Vermont (Erickson et al., 2013), and its variations were considered as potential tools for policy guidance in some nation states, e.g., through Australia's Measures of Progress (Kenny et al., 2019) and Germany's National and Regional Welfare Indices (Held et al., 2018). The suggested policy implications from the studies reviewed are listed in the last column of Appendix A and includes the potential to shape economic policy by identifying areas requiring intervention, raising awareness to about efficiency of and trade-offs between different policy choices, drawing attention to and quantifying both positive and negative welfare impacts of economic activity. If widely accepted and standardised, GPI has a potential to complement GDP and facilitate a wellbeing-centred policy goals, e.g. as sustainable scale where the costs of economic activity are minimised and benefits – maximised.

Perhaps the most significant GPI contribution to the policy debate to date lies in the disaggregation of positive and negative impacts of economic activity, and many of its practitioners seem to share the sentiment that *"GPI is an imperfect measure of full progress, but a significant improvement over GDP"* (Posner & Costanza, 2011, p. 1977). Some scholars contend it is a relatively simple metric that can be calculated using existing statistical data with no high additional costs and expressed in familiar monetary units (Kubiszewski et al., 2013), it measures progress over time, and if standardised, can be compared between countries (Berik, 2020). They argue that the purpose of the GPI is not to monetise everything relevant to welfare or replace GDP as a measure of market activity but to question its status as the main progress

performance indicator (*ibid.*). Among the obstacles to a wider implementation of the GPI in Europe, Berik (2020) lists the recession of the late 2000s and subsequent lack of resources, focus on economic growth, infrequent calculation of GPI, and scepticism about the usefulness of such a measure (*ibid.*). Kenny (2019) cites the lack of political will to prioritise wellbeing as an economic goal as an important obstacle for GPI implementation in the Australian context.

3.5 Standardised versus localised approach and the future of the GPI

There is an ongoing discussion in the literature on the need for GPI methodological alignment (Bagstad & Shammin, 2012; Forgie, 2007; Fox & Erickson, 2018; Kubiszewski et al., 2015; Posner & Costanza, 2011), which galvanised the GPI 2.0 methodology delineated by Talberth & Weisdorf (2017) and refined its theoretical basis, leading to an expanded range of sub-indicators and linking them to essential capital assets. Despite the extensive discussions concerning the development of the GPI 2.0 methodology, this new version has not gained traction since 2017 and was used only in four studies in this review (Cook & Davíðsdóttir, 2021b; Guan et al., 2024; Senna & Serra, 2021; Talberth & Weisdorf, 2017).

Twelve of the reviewed studies advocated a standardised GPI approach with unified methodology and data collection procedures resulting in comparable results across territories, while three context-specific others did not advocate this or were neutral in this regard (Appendix A). Held et al. (2018), Brown & Lazarus (2018), and Kenny et al. (2019) suggested a middle way approach of defining the “core” components of GPI that should be estimated in a standardised manner for comparable results but allowing for some flexibility to capture local nuances to best inform policy making.

This discussion is central to the GPI’s future direction. In the case of standardisation, significant methodological refinements are needed to align sub-indicator selection choices, valuation approaches and data collection practices (Bagstad et al., 2014; Brown & Lazarus, 2018; Posner & Costanza, 2011). The lack of uptake of the updated GPI 2.0 might be indicative of lack of agreement within the GPI community on these aspects. In a sign of the lack of consensus, Van der Slycken & Bleys (2023) propose another method that takes into consideration cross-time and boundary issues. In contrast to those seeking standardisation, Ostergaard-Klem & Oleson (2014), Delang & Yu (2014), and Hayashi (2015) suggest that the GPI should instead seek to reflect local realities and highlight the most significant costs and benefits of economic activity experienced within the territory examined.

3.6 Main methodological challenges of the GPI

The apparent lack of a shared vision for the future of the GPI among its practitioners is a major obstacle to further harmonisation and application. It is evident from the discussion above that GPI suffers from significant limitations, both methodological and in terms of its practical application. Firstly, choosing the adjustment items and monetisation methods requires assumptions and compromises, both in terms of selection of sub-indicators and methodological approaches, not least due to the lack of data (Dietz & Neumayer, 2006; Neumayer, 1999; Talberth & Weisdorf, 2017). This has led to divergence in methods, such as the number and breadth of sub-indicators, valuation approaches, selection of benchmarks, and theoretical groundings,

making comparisons between GPI studies difficult. Secondly, GPI is susceptible to subjective normative assumptions about what constitutes positive and negative contributions to human wellbeing. For instance, divorce is often included in GPI calculations as a cost, while it might be that overall economic wellbeing of those involved improved following separation. Similarly, some of the widely accepted human wellbeing components, such as political freedom, free speech, and gender equality is not reflected in GPI calculations.

Thirdly, limited data availability in most cases results in use of proxies and exclusion of sub-indicators for which there is no data available. This often makes GPI results inexact and difficult to compare. These factors result in the lack of standardisation and a common criticism that GPI lacks convention, and that the choice of sub-indicators is often arbitrary and very sensitive to availability of data, which results in limited comparability between studies (Forgie, 2007; Lazarus & Brown, 2022). Finally, in the “beyond GDP” literature, GPI is considered a weak sustainability indicator as it allows for substitution between human-made and natural capital (Held et al., 2018; Hoekstra, 2019; Huang, 2018), and while it presents a relatively simple calculation and a simple way of comparison, such substitution is not feasible in reality.

3.7 GPI and other sustainable wellbeing indicators

To address the weak sustainability issue, some of the studies reviewed suggest complementing GPI with a measure that refers to the Earth’s biocapacity, e.g., Ecological Footprint, Sustainable National Income, and the concept of Critical Natural Capital (Hanley et al., 1999; Huang, 2018; P. Lawn & Clarke, 2010; Li et al., 2022; Nourry, 2008; Patterson et al., 2019) or SEEA type accounts (Kenny et al., 2019). Nevertheless, such so-called “strong sustainability” indicators have their own flaws, e.g., inability to account for local ecological realities and lack of meaningful results that could inform policy (Fiala, 2008; van den Bergh & Grazi, 2014).

Cook and Davíðdóttir (2021a) compared GPI to GDP and other four alternative indicators of economic wellbeing (Environmentally Adjusted Net Domestic Product, Measure of Economic Welfare, Genuine Savings, and Inclusive Wealth Index) and found GPI to be the most comprehensive in coverage linking directly to 14 out of 17 SDGs as it accounts for market-based welfare, services from essential capital, and various environmental and social costs. This finding is in line with a recent comprehensive analysis of 65 “beyond GDP” metrics by Jansen et al. (2024), which found that GPI was one of the very few indexes that address all three criteria used: environmental sustainability, wellbeing, and inclusion. Other advantages of GPI include the fact that it uses a familiar money metric, is relatively easy to calculate without using additional resources or collecting additional primary data (Held et al., 2018; Kubizsewski et al., 2013; van den Bergh, 2022). Kenny et al. (2019) argue that integration of nature, social, economic, and built capital components and possibility of calculating historical time series comparable with GDP at national and sub-national scales is a unique advantage of GPI compared to other sustainable wellbeing indicators.

It is evident that GPI has both strengths and weaknesses compared to other “beyond GDP” indicators. Compared to strong sustainability indicators, it is easier to calculate and communicate to policy makers, but due to the limitations discussed above, it might not always be reliable if used on its own. No single indicator can capture the nuances of sustainable economic wellbeing and that the GPI could be one of several indicators used in a multidimensional

“wellbeing dashboard” to account for different aspects of wellbeing (Fioramonti, 2024; Karatopouzis et al., 2022), such as the United Nations [Valuing What Counts](#) initiative, Wealth Accounting and the Valuation of Ecosystem Services ([WAVES](#), 2024) partnership, and the Well-being, Inclusion and Sustainability ([WISE](#), 2024) database.

4 Future research, limitations and conclusions

4.1 Future research avenues

In the research environment, where there are an ever-increasing number of competing measures of various aspects of wellbeing and sustainable development, a shared vision and collaboration between scholars, practitioners, and wider society, is of paramount importance, as individual indices and composite indicators such as the GPI have a tendency to lose their relevance and fail to be taken into policy consideration if not agreed upon by different stakeholders (Hoekstra, 2019). Therefore, a wider debate on what measures are needed to supplement and/or complement GDP to reflect societal progress and wellbeing, and how individual indices and indicators can be included in this vision, is necessary. The WEAII alliance does this to some extent in their attempts to define what constitutes a wellbeing economy, yet much more work is needed in finalising and aligning these objectives with what is measured by economic wellbeing indices and indicators.

Some of the future research avenues suggested in the GPI literature include better defining its purpose and theoretical foundations (Held et al., 2018; Talberth & Weisdorf, 2017), solidifying the list of components (Fox & Erickson, 2018; Held et al., 2018), better estimation of ES flow values through dynamic spatial analysis (Bagstad & Shammin, 2012; Cook & Davíðsdóttir, 2021b), further analysis of trade-offs between indicators through system dynamics models (Cook & Davíðsdóttir, 2021b), and a possibility of using the GPI as a “simulation tool” for ex-ante policy analysis (Brown & Lazarus, 2018). Another apparent research avenue is conducting more GPI studies in middle- and lower-income countries and transition economies in different parts of the world, which has the potential to expand the body of literature beyond high income countries and reflect a wider spectrum of economic wellbeing realities. Even though the GPI is far from a perfect measure of macroeconomic wellbeing, it reveals some valuable information on the costs and benefits of economic growth, which may help to draw attention to the aspects of the economy where targeted action might be effective. Further development of valuation methods for estimating the contributions of natural capital components to economic wellbeing would be useful in the attempts to standardise the index and increase its attractiveness as a policy guiding tool.

4.2 Study limitations

As an ambitious undertaking of reviewing the GPI literature over almost three decades between 1995 and 2023, this study is not without limitations. The first limitation is related to the use of search words: title “GPI” was used, even though it was often used simultaneously with “ISEW”, especially in the first decade after the GPI’s inception, which likely resulted in identifying fewer studies (Hanley et al., 1999; P. Lawn, 2003; Posner & Costanza, 2011; Van der Slycken &

Bleys, 2023). However, since the purpose of the study was not a comprehensive list of all ISEW/GPI studies to date, this approach allowed for more of a qualitative focus on fewer studies that were published since 1995 using solely the GPI methodology, which differs slightly from the ISEW. The second limitation stems from solely searching for studies in English language databases, which may have resulted in overlooking studies from more diverse outlets and countries. Thirdly, looking only at academic publications may have limited the view of the applications of the GPI in a policy context, and this issue was partly addressed in the Section 3.4 by focusing on the policy implications of the GPI. Finally, any systematic review with qualitative elements such as this is susceptible to researcher bias, which were minimised following the best practice guides set out by (Booth et al., 2021; Mengist et al., 2020).

4.3 Conclusions

In the light of methodological divergencies and lack of clarity on GPI practical applications to date, this study attempted to provide an overview of GPI developments from 1995 to 2023, envisioning a way forward. The study presents a systematic literature review method to gain a better understanding of the main methodological approaches and policy applications of the GPI over the last three decades. A total of 43 primary GPI studies were sourced and analysed systematically to extract the main themes and trends. The results of the review suggest a lack of persistent trends and standardisation of the GPI method, with remaining contentions related to the theoretical foundations, valuation approaches, and availability of sufficient, high-quality data. The emergence of the GPI 2.0 methodology was a hopeful step towards resolving some of these issues but has not yet received a widespread attention in the literature, perhaps pointing to an ongoing debate in this area or even waning interest in the GPI. The review provides a timely contribution to the SDG Target 17.19 aiming to build on the existing knowledge to develop alternative metrics of progress on sustainable development that could complement GDP. Within the wide array of such metrics, the GPI has the appeal of a relatively simple composite indicator expressed in monetary terms that can help shift the focus away from purely economic growth fuelled by production and consumption towards improving economic wellbeing. Despite its limitations, GPI is still a more nuanced approximation of macroeconomic progress than considering economic output alone.

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References

- Andrade, D. C., & Garcia, J. R. (2015). Estimating the Genuine Progress Indicator (GPI) for Brazil from 1970 to 2010. *Ecological Economics*, 118, 49–56.
<https://doi.org/10.1016/J.ECOLECON.2015.07.018>
- Anielski, M. (2001). The Alberta GPI Blueprint. *Pembina Institute for Appropriate Development, Drayton Valley, Alberta*.
- Bagstad, K. J., Berik, G., & Gaddis, E. J. B. (2014). Methodological developments in US state-level Genuine Progress Indicators: Toward GPI 2.0. *Ecological Indicators*, 45, 474–485.
<https://doi.org/10.1016/J.ECOLIND.2014.05.005>
- Bagstad, K. J., Johnson, G. W., Voigt, B., & Villa, F. (2013). Spatial dynamics of ecosystem service flows: A comprehensive approach to quantifying actual services. *Ecosystem Services*, 4, 117–125. <https://doi.org/10.1016/J.ECOSER.2012.07.012>
- Bagstad, K. J., & Shammin, M. R. (2012). Can the Genuine Progress Indicator better inform sustainable regional progress?—A case study for Northeast Ohio. *Ecological Indicators*, 18, 330–341.
<https://doi.org/10.1016/J.ECOLIND.2011.11.026>
- Berik, G. (2020). Measuring what matters and guiding policy: An evaluation of the Genuine Progress Indicator. *International Labour Review*, 159(1), 71–94. <https://doi.org/https://doi.org/10.1111/ilr.12153>
- Berik, G., & Gaddis, E. (2011). *The UTah GenUine ProGress indicaTor (GPi), 1990 To 2007*.
- Booth, A., Sutton, A., Clowes, M., & Martyn-St James, M. (2021). *Systematic approaches to a successful literature review*. Sage.
- Brown, C., & Lazarus, E. (2018). Genuine Progress Indicator for California: 2010–2014. *Ecological Indicators*, 93, 1143–1151. <https://doi.org/10.1016/J.ECOLIND.2018.05.072>
- Brundtland, G. H., & Khalid, M. (1987). *Our common future*. Oxford University Press, Oxford, GB.
- Clarke, M. (2007). Is the Genuine Progress Indicator really genuine? Considering well-being impacts of exports and imports. *International Journal of Environment, Workplace and Employment*, 3(2), 91–102.
<https://doi.org/10.1504/IJEWE.2007.017877>
- Clarke, M., & Lawn, P. (2005). Measuring Victoria's genuine progress: a Genuine Progress Indicator (GPI) for Victoria. *Economic Papers: A Journal of Applied Economics and Policy*, 24(4), 368–389.
<https://doi.org/https://doi.org/10.1111/j.1759-3441.2005.tb01009.x>
- Clarke, M., & Lawn, P. (2008). Is measuring genuine progress at the sub-national level useful? *Ecological Indicators*, 8(5), 573–581. <https://doi.org/10.1016/J.ECOLIND.2007.08.002>
- Cobb, C., Halstead, T., & Rowe, J. (1995). *The genuine progress indicator: summary of data and methodology* (Vol. 15). Redefining Progress San Francisco.
- Cobb, J., & Daly, H. (1989). *For the common good, redirecting the economy toward community, the environment and a sustainable future*. Boston: Beacon Press.

- Cook, D., & Davíðsdóttir, B. (2021a). An appraisal of interlinkages between macro-economic indicators of economic well-being and the sustainable development goals. *Ecological Economics*, 184, 106996. <https://doi.org/10.1016/J.ECOLECON.2021.106996>
- Cook, D., & Davíðsdóttir, B. (2021b). An estimate of the Genuine Progress Indicator for Iceland, 2000–2019. *Ecological Economics*, 189, 107154. <https://doi.org/10.1016/J.ECOLECON.2021.107154>
- Cook, D., & Davíðsdóttir, B. (2022). A preliminary estimate of the economic value of Iceland's terrestrial ecosystem services and opportunities for future research. *Sustainable Futures*, 4, 100076. <https://doi.org/10.1016/J.SFTR.2022.100076>
- Cook, D., Malinauskaite, L., Davíðsdóttir, B., & Ögmundardóttir, H. (2022). Capital assets underpinning economic well-being – The example of whale ecosystem services in Arctic coastal communities. *Ecosystem Services*, 55, 101432. <https://doi.org/10.1016/J.ECOSER.2022.101432>
- Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R. V., Paruelo, J., Raskin, R. G., Sutton, P., & van den Belt, M. (1997). The value of the world's ecosystem services and natural capital. *Nature*, 387(6630), 253–260. <https://doi.org/10.1038/387253a0>
- Costanza, R., Erickson, J., Fligger, K., Adams, A., Adams, C., Altschuler, B., Balter, S., Fisher, B., Hike, J., Kelly, J., Kerr, T., McCauley, M., Montone, K., Rauch, M., Schmiedeskamp, K., Saxton, D., Sparacino, L., Tusinski, W., & Williams, L. (2004). Estimates of the Genuine Progress Indicator (GPI) for Vermont, Chittenden County and Burlington, from 1950 to 2000. *Ecological Economics*, 51(1–2), 139–155. <https://doi.org/10.1016/J.ECOLECON.2004.04.009>
- Costanza, R., Fioramonti, L., Kubiszewski, I., Markowitz, D., Orr, C., Trebeck, K., & Wallis, S. (2020). Creating a Wellbeing Economy Alliance (WEAll) to motivate and facilitate the transition. In *Sustainable Wellbeing Futures* (pp. 399–407). Edward Elgar Publishing.
- Costanza, R., & Patten, B. C. (1995). Defining and predicting sustainability. *Ecological Economics*, 15(3), 193–196. [https://doi.org/10.1016/0921-8009\(95\)00048-8](https://doi.org/10.1016/0921-8009(95)00048-8)
- Daly, H. E., & Farley, J. (2011). *Ecological economics: principles and applications*. Island press.
- Danilishin, B. M., & Veklich, O. A. (2010). Genuine progress indicator as an adequate macroeconomic indicator of public welfare. *Studies on Russian Economic Development*, 21, 644–650.
- Delang, C. O. (2016). Development beyond growth: Singapore's genuine progress, 1968–2014. *International Journal of Green Economics*, 10(1), 32–50.
- Delang, C. O., & Yu, Y. H. (2014). Beyond economic growth: the genuine progress of Hong Kong from 1968 to 2010. *International Journal of Sustainable Development*, 17(4), 387–402.
- Dietz, S., & Neumayer, E. (2006). Some constructive criticisms of the Index of Sustainable Economic Welfare. *Sustainable Development Indicators in Ecological Economics*, 2006, 186–206.
- Erickson, J. D., Zencey, E., Burke, M. J., Carlson, S., & Zimmerman, Z. (2013). *Vermont Genuine Progress Indicator*.

- Feeny, S., Mitchell, H., Tran, C., & Clarke, M. (2013). The Determinants of Economic Growth Versus Genuine Progress in South Korea. *Social Indicators Research*, 113(3), 1055–1074.
<https://doi.org/10.1007/s11205-012-0127-4>
- Fiala, N. (2008). Measuring sustainability: Why the ecological footprint is bad economics and bad environmental science. *Ecological Economics*, 67(4), 519–525.
<https://doi.org/10.1016/J.ECOLECON.2008.07.023>
- Fioramonti, L. (2024). Post-growth theories in a global world: A comparative analysis. *Review of International Studies*, 1–11. <https://doi.org/DOI: 10.1017/S0260210524000214>
- Fisher, I. (1906). *The nature of capital and income*. Macmillan.
- Fitouss, J.-P., Stiglitz, J. E., & Sen, A. K. (2011). *Mismeasuring our lives: why GDP doesn't add up*. ReadHowYouWant. com.
- Forge, V. (2007). The need for “convention” in environmental valuation. *International Journal of Environment, Workplace and Employment*, 3(2), 72–90.
<https://doi.org/10.1504/IJEWE.2007.017876>
- Fox, M. J. V., & Erickson, J. D. (2018). Genuine Economic Progress in the United States: A Fifty State Study and Comparative Assessment. *Ecological Economics*, 147, 29–35.
<https://doi.org/10.1016/J.ECOLECON.2018.01.002>
- Giannetti, B. F., Agostinho, F., Almeida, C. M. V. B., & Huisingh, D. (2015). A review of limitations of GDP and alternative indices to monitor human wellbeing and to manage eco-system functionality. *Journal of Cleaner Production*, 87(1), 11–25. <https://doi.org/10.1016/J.JCLEPRO.2014.10.051>
- Goodwin, N. R. (2003). *Five kinds of capital: Useful concepts for sustainable development*.
<https://doi.org/10.22004/ag.econ.15595>
- Grant, M. J., & Booth, A. (2009). A typology of reviews: an analysis of 14 review types and associated methodologies. *Health Information & Libraries Journal*, 26(2), 91–108.
<https://doi.org/https://doi.org/10.1111/j.1471-1842.2009.00848.x>
- Guan, C., Weng, Y., Zhao, J., Lin, Y., Zhang, W., & Tu, Q. (2021). Examining China’s sustainable development based on genuine progress indicator. *Sustainable Production and Consumption*, 28, 1635–1644.
<https://doi.org/10.1016/J.SPC.2021.09.007>
- Guan, C., Yang, P., Yang, H., & Zhang, J. (2024). Is the Genuine Progress Indicator a Better Policy Goal for Sustainable Development? An Empirical Study Based on the Environmental Kuznets Curve. *Social Indicators Research*, 171(1), 47–86. <https://doi.org/10.1007/s11205-023-03237-z>
- Hamilton, C. (1999). The genuine progress indicator methodological developments and results from Australia. *Ecological Economics*, 30(1), 13–28. [https://doi.org/10.1016/S0921-8009\(98\)00099-8](https://doi.org/10.1016/S0921-8009(98)00099-8)
- Hanley, N., Moffatt, I., Faichney, R., & Wilson, M. (1999a). Measuring sustainability: A time series of alternative indicators for Scotland. *Ecological Economics*, 28(1), 55–73.
[https://doi.org/10.1016/S0921-8009\(98\)00027-5](https://doi.org/10.1016/S0921-8009(98)00027-5)

- Hanley, N., Moffatt, I., Faichney, R., & Wilson, M. (1999b). Measuring sustainability: A time series of alternative indicators for Scotland. *Ecological Economics*, 28(1), 55–73.
[https://doi.org/10.1016/S0921-8009\(98\)00027-5](https://doi.org/10.1016/S0921-8009(98)00027-5)
- Hashim, M., Mohamad, A., & Sifat, I. M. (2019). The sustainable development consequences of IMF debt vs. capital control: Comparing progress in GPI and GDP terms for Korea and Malaysia. *Journal of Cleaner Production*, 234, 725–742. <https://doi.org/10.1016/J.JCLEPRO.2019.06.144>
- Hayashi, T. (2015). Measuring rural–urban disparity with the Genuine Progress Indicator: A case study in Japan. *Ecological Economics*, 120, 260–271. <https://doi.org/10.1016/J.ECOLECON.2015.11.006>
- Held, B., Rodenhäuser, D., Diefenbacher, H., & Zieschank, R. (2018). The National and Regional Welfare Index (NWI/RWI): Redefining Progress in Germany. *Ecological Economics*, 145, 391–400.
<https://doi.org/10.1016/J.ECOLECON.2017.11.026>
- Hoekstra, R. (2019). *Replacing GDP by 2030: Towards a common language for the well-being and sustainability community*. Cambridge University Press.
- Hou, Y. (2017). Calculating a GPI for Liaoning Province of China. *Social Indicators Research*, 134(1), 263–276. <https://doi.org/10.1007/s11205-016-1415-1>
- Huang, L. (2018). Exploring the strengths and limits of strong and weak sustainability indicators: a case study of the assessment of China’s megacities with EF and GPI. *Sustainability*, 10(2), 349.
- Jansen, A., Wang, R., Behrens, P., & Hoekstra, R. (2024). Beyond GDP: a review and conceptual framework for measuring sustainable and inclusive wellbeing. *The Lancet Planetary Health*, 8(9), e695–e705.
- Kamali Saraji, M., & Streimikiene, D. (2023). Challenges to the low carbon energy transition: A systematic literature review and research agenda. *Energy Strategy Reviews*, 49, 101163.
<https://doi.org/10.1016/J.ESR.2023.101163>
- Karatopouzis, A., Voinov, A. A., Kubiszewski, I., Taghikhah, F., Costanza, R., & Kenny, D. (2022). Estimating the Genuine Progress Indicator before and during the COVID pandemic in Australia. *Ecological Indicators*, 141, 109025. <https://doi.org/10.1016/J.ECOLIND.2022.109025>
- Kenny, D. C., Costanza, R., Dowsley, T., Jackson, N., Josol, J., Kubiszewski, I., Narulla, H., Sese, S., Suintanto, A., & Thompson, J. (2019). Australia’s Genuine Progress Indicator Revisited (1962–2013). *Ecological Economics*, 158, 1–10. <https://doi.org/10.1016/J.ECOLECON.2018.11.025>
- Kubiszewski, I., Costanza, R., Franco, C., Lawn, P., Talberth, J., Jackson, T., & Aylmer, C. (2013). Beyond GDP: Measuring and achieving global genuine progress. *Ecological Economics*, 93, 57–68.
<https://doi.org/10.1016/J.ECOLECON.2013.04.019>
- Kubiszewski, I., Costanza, R., Gorko, N. E., Weisdorf, M. A., Carnes, A. W., Collins, C. E., Franco, C., Gehres, L. R., Knobloch, J. M., Matson, G. E., & Schoepfer, J. D. (2015). Estimates of the Genuine Progress Indicator (GPI) for Oregon from 1960–2010 and recommendations for a comprehensive shareholder’s report. *Ecological Economics*, 119, 1–7.
<https://doi.org/10.1016/J.ECOLECON.2015.08.004>

- Kusago, T. (2007). Rethinking of Economic Growth and Life Satisfaction in Post-WWII Japan - A Fresh Approach. *Social Indicators Research*, 81(1), 79–102.
<https://doi.org/https://doi.org/10.1007/s11205-006-0016-9>
- Kuznets, S. (1934). National Income, 1929-1932. In *National Income, 1929-1932* (pp. 1–12). NBER.
- Lawn, P. (2003). A theoretical foundation to support the Index of Sustainable Economic Welfare (ISEW), Genuine Progress Indicator (GPI), and other related indexes. *Ecological Economics*, 44(1), 105–118. [https://doi.org/10.1016/S0921-8009\(02\)00258-6](https://doi.org/10.1016/S0921-8009(02)00258-6)
- Lawn, P. (2005). An Assessment of the Valuation Methods Used to Calculate the Index of Sustainable Economic Welfare (ISEW), Genuine Progress Indicator (GPI), and Sustainable Net Benefit Index (SNBI). *Environment, Development and Sustainability*, 7(2), 185–208. <https://doi.org/10.1007/s10668-005-7312-4>
- Lawn, P. A., & Clarke, M. (2008). *Sustainable welfare in the Asia-Pacific: studies using the genuine progress indicator*. Edward Elgar Publishing.
- Lawn, P., & Clarke, M. (2010). The end of economic growth? A contracting threshold hypothesis. *Ecological Economics*, 69(11), 2213–2223. <https://doi.org/10.1016/J.ECOLECON.2010.06.007>
- Lazarus, E., & Brown, C. (2022). Improving the genuine progress indicator to measure comparable net welfare: U.S. and California, 1995–2017. *Ecological Economics*, 202, 107605.
<https://doi.org/10.1016/J.ECOLECON.2022.107605>
- Li, Y., Qiao, J., Xie, L., Huang, L., Su, Y., Zhou, M., Wang, K., Zhang, J., He, S., & Huang, L. (2022). Assessing economic sustainability and ecological efficiency with genuine progress indicator: a case study of the Yangtze River Delta from 2000 to 2018. *Environmental Science and Pollution Research*, 29(31), 46751–46766.
- Long, X., & Ji, X. (2019). Economic Growth Quality, Environmental Sustainability, and Social Welfare in China - Provincial Assessment Based on Genuine Progress Indicator (GPI). *Ecological Economics*, 159, 157–176. <https://doi.org/10.1016/J.ECOLECON.2019.01.002>
- Makino, M. (2008). Genuine Progress Indicator (GPI) for Japan: Revised Estimation 1970-2003. *Working Paper*, 216, 1–47.
- Malinauskaite, L., Cook, D., Davíðsdóttir, B., Ögmundardóttir, H., & Roman, J. (2019). Ecosystem services in the Arctic: a thematic review. *Ecosystem Services*, 36, 100898.
<https://doi.org/10.1016/J.ECOSER.2019.100898>
- Max-Neef, M. (1995). Economic growth and quality of life: a threshold hypothesis. *Ecological Economics*, 15(2), 115–118.
- Mengist, W., Soromessa, T., & Legese, G. (2020). Method for conducting systematic literature review and meta-analysis for environmental science research. *MethodsX*, 7, 100777.
<https://doi.org/10.1016/J.MEX.2019.100777>
- Neumayer, E. (1999). The ISEW: Not an Index of Sustainable Economic Welfare. *Social Indicators Research*, 48(1), 77–101. <http://www.jstor.org/stable/27522403>

- Nourry, M. (2008). Measuring sustainable development: Some empirical evidence for France from eight alternative indicators. *Ecological Economics*, 67(3), 441–456.
<https://doi.org/10.1016/J.ECOLECON.2007.12.019>
- Ollivier, T., & Giraud, P.-N. (2010). The usefulness of sustainability indicators for policy making in developing countries: the case of Madagascar. *The Journal of Environment & Development*, 19(4), 399–423.
- Ostergaard-Klem, R., & Oleson, K. L. L. (2014). GPI island style: localizing the genuine progress indicator to Hawaii. *Environmental Practice*, 16(3), 182–193.
- Pais, D. F., Afonso, T. L., Marques, A. C., & Fuinhas, J. A. (2019). Are economic growth and sustainable development converging?: evidence from the comparable genuine progress indicator for organisation for economic co-operation and development countries. *International Journal of Energy Economics and Policy*, 9(4), 202–213.
- Patterson, M., McDonald, G., Forgie, V., Kim, J. H., Hardy, D., Smith, N., & Zhang, Y. (2019). *Beyond Gross Domestic Product: The New Zealand Genuine Progress Indicator to Measure the Economic, Social and Environmental Dimensions of Well-being from 1970-2016*.
- Posner, S. M., & Costanza, R. (2011). A summary of ISEW and GPI studies at multiple scales and new estimates for Baltimore City, Baltimore County, and the State of Maryland. *Ecological Economics*, 70(11), 1972–1980. <https://doi.org/10.1016/J.ECOLECON.2011.05.004>
- Raworth, K. (2017). *Doughnut economics: Seven ways to think like a 21st-century economist*. Chelsea Green Publishing.
- Røpke, I. (2004). The early history of modern ecological economics. *Ecological Economics*, 50(3–4), 293–314. <https://doi.org/10.1016/J.ECOLECON.2004.02.012>
- Senna, G. N., & Serra, E. G. (2021). Estimating the Genuine Progress Indicator (GPI) for the State of Rio de Janeiro, Brazil, from 2002 to 2016, as a tool for public policy decision making. *Environment, Development and Sustainability*, 23(11), 16325–16342. <https://doi.org/10.1007/s10668-021-01350-y>
- Serafy, E. L. (1989). The proper calculation of income from depletable natural resources. *Environmental Accounting for Sustainable Development, A UNEP-World Bank Symposium*.
- State of Maryland. (2024). *Maryland Genuine Progress Indicator*. <https://Dnr.Maryland.Gov/Mdgp/Default.aspx>.
- Talberth, J., Cobb, C., & Slattery, N. (2007). The Genuine Progress Indicator 2006: A Tool for Sustainable Development. *Oakland, CA: Redefining Progress*, 26.
- Talberth, J., & Weisdorf, M. (2017). Genuine Progress Indicator 2.0: Pilot Accounts for the US, Maryland, and City of Baltimore 2012–2014. *Ecological Economics*, 142, 1–11.
<https://doi.org/10.1016/J.ECOLECON.2017.06.012>
- UN. (2012). *System of Environmental-Economic Accounting 2012: Central Framework*. International Monetary Fund.

- Van den Bergh, J. C. J. M. (2007). *Abolishing GDP*.
<https://doi.org/http://dx.doi.org/10.2139/ssrn.962343>
- van den Bergh, J. C. J. M. (2022). A procedure for globally institutionalizing a ‘beyond-GDP’ metric. *Ecological Economics*, 192, 107257. <https://doi.org/10.1016/J.ECOLECON.2021.107257>
- van den Bergh, J. C. J. M., & Grazi, F. (2014). Ecological Footprint Policy? Land Use as an Environmental Indicator. *Journal of Industrial Ecology*, 18(1), 10–19.
<https://doi.org/https://doi.org/10.1111/jiec.12045>
- Van der Ploeg, S., De Groot, R. S., & Wang, Y. (2010). The TEEB Valuation Database: overview of structure, data and results. *Foundation for Sustainable Development, Wageningen, the Netherlands*, 1–247.
- Van der Slycken, J., & Bleys, B. (2023). Towards ISEW and GPI 2.0: Dealing with Cross-Time and Cross-Boundary Issues in a Case Study for Belgium. *Social Indicators Research*, 168(1), 557–583.
<https://doi.org/10.1007/s11205-023-03142-5>
- Van der Slycken, J., & Bleys, B. (2024). Is Europe faring well with growth? Evidence from a welfare comparison in the EU-15 (1995–2018). *Ecological Economics*, 217, 108054.
<https://doi.org/10.1016/J.ECOLECON.2023.108054>
- Wen, Z., Zhang, K., Du, B., Li, Y., & Li, W. (2007). Case study on the use of genuine progress indicator to measure urban economic welfare in China. *Ecological Economics*, 63(2–3), 463–475.
<https://doi.org/10.1016/J.ECOLECON.2006.12.004>
- WISE. (2024). *WISE Database*. <https://www.beyond-Gdp.World/Wise-Database/Wise-Database>.

Appendix A. The overview of the publications included in the review.

Number	Reference	Year published	Location	Scale	Years covered	Journal/ outlet	Motivation	Number of indicators	Indicators/type of capital	Stated method innovations	Common data sources	Main KN accounting methods	Stated KN method innovations	Standardised vs. local approach	Relation to GDP	Supplement with other indicators?	Stated policy implications
1.	Hanley et al. (1999)	1999	Scotland	National	1980-1993	Ecological Economics	To provide a time-series analysis of 7 alt. wellbeing indicators, including GPI, for Scotland, comparing their usefulness for measuring sustainable development	Not indicated	N/A	One of the first to apply GPI instead of ISEW, include loss of leisure time, under-employment, forestry loss	UK and Scottish Statistics Offices, Department of Environment; previous GPI studies	Damage costs from pollution, cost of changes in forest and wetland area	Adding cost of forest loss and omitting ozone depletion as not relevant	Does not indicate	GPI starts at 1/3 of GDP in 1980 and falls over time while GDP grows	Net National Product, Genuine Savings, Ecological Footprint, Environmental Space, Net primary Productivity	GPI is one of the ways to measure sustainable development that has a potential to highlight welfare impacts of economic growth
2.	Hamilton (1999)	2003	Australia	National	1950-1996	Ecological Economics	To improve GPI methodology by applying a systematic approach to some components and apply it to Australia	25	Built & financial: 7; social: 8; human: 2; natural: 8	Adapted methods for the costs of ozone depletion and use of irrigation water	Australia Institute, Department of Environment, Bureau of Transport and Communications Economics	Damage costs from pollution, costs of climate change, irrigation, land degradation, loss of native forests, ozone and NRE depletion	Improved methods for the costs of ozone depletion and use of irrigation water	Does not indicate	Starts at the same level in the 1950 and grows at a similar rate until 1970s when it starts diverging down	GDP	Ability to highlight welfare impacts of economic growth on different types of capital
3.	Costanza et al. (2004)	2004	US state of Vermont, Chittenden County and Burlington	Sub-national: state & city	1950-2000	Ecological Economics	To present the first multi-scale application of GPI at the city, county and state levels, demonstrating the feasibility and comparability of GPI across scales and with US national average	26	Built and financial: 8; social: 6; human: 3; natural: 9	First to apply GPI at multiple scales, divide into 8 functional groups: income, mobility, KS, pollution, land loss, NK, net investment	US Bureau of Economic Affairs, Department of Labour, Energy Information Administration, EPA, previous studies	Cost of pollution, cost of lost wetlands, farmlands, forest, long-term damage of carbon emissions	Cumulative cost of lost wetland, farmland, long-term environmental damage from baseline year	Standardise	No comparison provided	Other revised indicators with survey data	Ability to account for costs and benefits of economic progress, highlighting which areas of economy need targeted policies
4.	Clarke & Lawn (2005)	2005	Australian state of Victoria	Sub-national: state	1986-2003	Applied Economics and Policy	To present an improved GPI methodology	20	Built & financial: 6; social:	Expanded list of defensive and rehabilitative	Australian Bureau of Statistics, Department	Cost of pollution, long-term	Lost NK services, use of Ecosystem	Not discussed	GPI starts at around 70% of GDP,	No	Accounts for social and environmental

Number	Reference	Year published	Location	Scale	Years covered	Journal/ outlet	Motivation	Number of indicators	Indicators/type of capital	Stated method innovations	Common data sources	Main KN accounting methods	Stated KN method innovations	Standardised vs. local approach	Relation to GDP	Supplement with other indicators?	Stated policy implications
							and apply it to the State of Victoria, estimating its GPI and reviewing the impact of economic growth on well-being		6; natural: 8	expenditures, added NK indicators, publicly provided service capital	of Environment, previous studies	environmental damage, lost NK services, NRS, irrigation water use, Ecosystem Health Index	Health Index to account for cost of vegetation loss, include timber depletion,		growing 1.5% and 2.5% p.a., respectively, starting to diverge significantly from 1995		costs that can be addressed through targeted policies
5.	Forgie (2007)	2007	New Zealand	National	1970-2005	Environment, Workplace & Employment	To highlight the need for better alignment in GPI methods and examine the NK and ES valuation approaches and possibilities for harmonisation	23	Built & financial: 5; social: 6; human: 2; natural: 10	Expanded list of natural capital indicators and calculation methods	New Zealand Government, New Zealand Statistical Office, previous studies	Resource rent, cost of lost life, ES loss, loss of environmental quality, damage from carbon emissions	Cost of lost soils, water and air quality, contaminated sites, damage from pests, loss of life from pollution, resource rent in NRR	Standardise	GPI significantly lower than GDP: in 2005, total GDP was \$148.9 billion, while GPI was \$91 billion	Not discussed	If standardised, has a potential to serve as an alternative to GDP for measuring wellbeing performance and guide policy
6.	Kusago (2007)	2007	Japan	National and sub-national (prefecture)	1955-2002	Social Indicators Research	To compare GDP and GPI in Japan and prefecture-based rankings of GDP, HDI, and Life Satisfaction, analysing links between economic growth and life satisfaction	10	financial & built: 3; social: 3; human: 1; natural: 3	Not disclosed	Ohashi et al., 2003, Statistics Bureau of Japan	Cost of pollution, carbon emissions, NRR depletion	Not stated	Not discussed	At a similar level in 1955, but since 1970s GPI growth much slower, resulting in only 40% of GDP in 2002	Human development Index, subjective life satisfaction	Highlights wellbeing effects of economic growth and can be used as an alternative to GDP to inform decision-making
7.	Talberth et al. (2007)	2007	The United States	National	1950-2004	Redefining Progress	To suggest an updated GPI methodology, apply it to the US, and explain its suitability to measure sustainable development	26	Built & financial: 8; social: 6; human: 2; natural: 10	Updated data sources, spill over effects of education, using benchmarks for leisure time and natural capital loss	Bureaus of Labour Statistics and Economic Analysis, Time Use Surveys, EPA, past studies	Cost of pollution abatement, social cost of soil erosion and carbon, replacement costs of NRR with biofuels	Cumulative damage from carbon emissions and lost ES since historic benchmarks, new data sources	Standardise	GPI annual growth p.c. was 1.33%, while GDP 3.81%, diverging greatly since 1980	Does not discuss	GPI points to reduction of economic welfare by economic openness, certain tax cuts and urban sprawl

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8.	Wen et al. (2007)	2007	Four cities in China: Suzhou, Yangzhou, Ningbo, and Guangzhou	Sub-national: city	1991-2001	Ecological Economics	To evaluate the economic performance and human wellbeing in urban China using GPI, demonstrating the deficiencies of GDP as a measure of economic performance	23	Built & financial: 7; social: 7; natural: 9	Applying GPI for 4 cities in China, using local data, comparing results, using clean-up costs and Human Capital Approach (HCA) to estimate pollution	Statistic Year-books of the local Bureau of Statistics in China, previous studies	Net price method in NNR depletion, lost ES from wetlands and forests, lost productivity from farmland	Cost of wetland loss with 10% annual increase rate, NRR using market price + extraction, WTP, HCA and clean-up costs of env. pollution	Does not discuss specifically, but adapts the study to the local context	Example: GPI in Guangzhou in 1991 was 29,8% of GDP, and in 2001 - 17.4%, as GPI grew 13% and GDP 19%.	Does not discuss	GPI reveals need for better social security system, energy efficiency, farmland and wetland protection, and pollution reduction.
9.	Makino (2008)	2008	Japan	National	1970-2003	Hyogo University	To calculate GPI for Japan, revising the method and estimates by the previous studies	11	Built & financial: 4; social: 3; natural: 4	Uses Atkinson Index for inequality adjustment, more cautious approach to treatment of defensive expenditures and services from capital	Japanese Statistics Bureau, Government Ministries, National Agricultural Research Centre, previous studies	Prevention costs of degradation, costs of damage to NK, user cost method for NRR, cost of pollution and its prevention	User cost method for NRR depletion with 2% interest rate, local estimates of timber and farmland values	Not discussed	Per capita GPI grew slower than GDP: 0.731 to 1.984M yen compared to 1.785 to 4.056 M yen	Does not discuss	Suggests that GPI is better indicator of welfare than GDP, but could be improved by accounting for imported resource use
10.	Nourry (2008)	2008	France	National	1990-2002	Ecological Economics	To provide a time-series analysis of 8 alternative well-being indexes in France, highlighting theoretical underpinnings, advantages, drawbacks, and suitability to measure SD	25	Built & financial: 6; social: 6; human: 4; natural: 9	Higher rate of fossil fuel tax, replacement cost with 3% annual increase in NRR depletion; omitted a few components due to lack of data/relevance	French Statistical Institute, French institute of Environment, OECD, European Environmental Agency, previous studies	Benefit transfer of marginal social costs for pollution and farmland loss, replacement cost of NRR, cumulative oil tax, personal pollution control	Increased rate of fossil fuel tax in method for long term environmental damage, replacement cost with 3% annual increase for NRR depletion	Does not mention	GPI per capita less than 1/2 of GDP per capita; until 1997 both increased, after that diverging, GPI showing unstable trends	Genuine Savings, Ecological Footprint, Pollution-sensitive Human Development Index, Sustainable Human Development Index	GPI has a potential to highlight social and environmental costs of economic growth, suggesting areas for improvement
11.	Ollivier & Giraud (2010)	2010	Madagascar	National	1980-2004	Environment & Development	To compare the practical policy implications that can be derived	11	Built & financial: 4; social: 2;	Not indicated	World Health Organisation, World Institute for Development Economics	Mortality cost of pollution, damage cost of CO2, cost of logging and	3.5% loss of GDP due to CO2 damage, with marginal cost of 50USD	Does not discuss	GPI per capita started at around 85% of GDP and increased	Adjusted Net Savings and Ecological Footprint	Limited policy application due to ambiguity of purpose between

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							from three aggregate sustainability indicators: GPI, Adjusted Net Savings, and Ecological Footprint		human: 1; natural: 4		Research, Food and Agriculture Organisation, World Bank, previous studies	not forest products	per ton of carbon		over time as GDP declined, to 125% of GDP in 2002		present welfare and sustainability
12.	Lawn & Clarke (2010)	2010	Selected Asia-Pacific countries: Australia, New Zealand, Japan, China, India, Thailand, and Vietnam	Multi-national	1967-2006	Ecological Economics	To provide empirical evidence for “contracting threshold hypothesis” implying that economic growth in the globalised world result in contraction in the threshold at which GDP exceeds GPI	17	Built & financial: 7; social: 5; natural: 5	Not indicated	Previous studies, Lawn & Clarke (2008) book	Not indicated	Opportunity cost of NRR and timber stocks, annual cost of pollution clean-up, cost of compensation to citizens for long-term impact of energy consumption	None stated	Threshold level at which GDP starts exceeding GPI significantly contracts over time as economies expand collectively	Biophysical indicator, such as Ecological Footprint	Threshold at which costs of economic growth exceed benefits is reached at increasingly lower levels over time, suggest moving away from growth
13.	Danilishin & Veklich (2010)	2010	Ukraine	National	2007-2007	Studies on Russian Economic Development	To calculate GPI for Ukraine, demonstrating its benefits as a welfare indicator, comparing to GDP and drawing conclusions about progress	12	Built & financial & built: 6; social: 2; natural: 4	None stated	State Statistics Service of Ukraine, previous studies	Cost of water and air pollution, loss of farmland	None stated	Not stated	In 2006, GDP over GPI ratio ranges between 2.3 and 5.3 times (approximate results)	Does not indicate	GPI can guide priority setting in national policy and business decisions to achieve wider wellbeing objectives
14.	Posner & Costanza (2011)	2011	US state of Baltimore, Baltimore County, and the State of Maryland	Sub-national: state and county	1950-2005	Ecological Economics	To provide an overview of GPI/ISEW studies up to 2011, estimate GPI for the case study locations, comparing results	25	Built & financial: 7; social: 7; human: 1; natural: 10	Omit education, use 1940s baseline for adjustment of wetland, forest, and farmland loss, distinguish between NRR use	US Bureau of Economic Affairs, Department of Labour, Energy Information Administration, EPA, previous studies	Loss of ES from wetlands, forests, farmlands, replacement cost of NRR, cost of pollution, social cost of carbon	Distinguish between uses of NRR, use 1940 benchmark for loss of ES, 1950 for CO2 damage,	Standardise	GPI starts at around 50% of GDP in 1950 and mirrors its growth up to 1990, after that growing 4 times	Not stated	Can add value to policy design by highlighting the benefits from natural and social capital, and by facilitating debate

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										for electricity and transport					slower than GDP		
15.	Bagstad & Shammin (2012)	2012	US state of Ohio, cities of Akron and Cleveland, 17 Northeast Ohio counties	Sub-national: state, city and county	1990-2005	Ecological Indicators	To articulate limitations mainstream indicators, present GPI as alternative, adjust and apply it in the case studies, evaluate trends, and inter- and intra-regional comparisons	26	Built & financial: 7; social: 9; human: 1; natural: 9	Include new non-market valuation estimates of ES values, consider carbon embedded in consumption	US Census Bureau, Bureau of Labour Statistics, American Time Use Survey, Department of Agriculture, Forest Service, EPA, Energy Information Administration	Replacement cost in NRR depletion, consumer spending and GHG intensity per \$ for climate change costs, cost of pollution and abatement	Considers new studies on ES valuation and life cycle estimates of carbon embodied in consumer spending	Not stated	Not stated	Not stated	Can be used as a decision tool for local and regional development and help engage stakeholders in discussions on goals and policies
16.	Feeny et al. (2013)	2013	South Korea	National	1970-2005	Social Indicators Research	To calculate GPI for South Korea and identify the determinants of growth in GDP and GPI per capita	10	Built & financial: 7; social: 2; natural: 1	None	World Bank, OECD, IMF, Korean Ministry of Environment	Only cost of air pollution included	Cost of air pollution control to the Korean Republic	Standardise	Start at the same level in 1970 with similar growth rates until 1998, then diverge	Not stated	Provide a more comprehensive perspective of a nation's welfare
17.	Delang & Yu (2014)	2014	Hong Kong	National	1968-2010	Sustainable Development	To estimate GPI, presenting results for all items of the economic, environmental and social sub-indices, and comparing trends with GPI and GDP	25	Built & financial: 7; social: 8; natural: 10	Includes extensive list of items in defensive and rehabilitative expenditures, services fixed built capital, fisheries, solid waste, carbon sequestration	Hong Kong Statistical Yearbook, Departments of Information Services and Census and Statistics, Hong Kong University, prior studies	Benefit transfer for lost ES, El Serafy's replacement cost for NRR and fisheries depletion, pollution mitigation costs	Include cost of fisheries depletion, solid waste, value of carbon sequestration, direct dis-amenity of pollution	Allow for regional differences	Start at a similar level and slowly diverge, GDP growing faster and GPI plateauing in 2007	Not stated	Contribute to the debate on sustainable welfare and the best ways to increase it, highlighting problematic areas
18.	Ostergaard-Klem & Oleson (2014)	2014	US state of Hawaii	Sub-national: state	2000-2009	Environmental Practice	To argue for localised GPI approach and against scaling down national data and value transfer, and	26	Built & financial: 8; social: 6; human: 2; natural: 10	Exclude air pollution, ozone depletion and cost of family changes, use de facto population	US Bureau of Economic Analysis, Hawaii State, Environmental Council, Office of Hawaiian	Not stated, but use the same methods as State of Maryland (2010)	Suggest omitting cost of air pollution and ozone depletion, argue for nuanced	Local	GPI is around 25-30% below GDP over the study period, and show similar	Not stated	GPI process helps to uncover costs and benefits of economic growth, and highlight

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							suggest adjusting it to local contexts			to account for many visitors	Affairs, University of Hawaii		consideration of local NK		growth trends		issues unique to local setting
19.	Andrade & Garcia (2015)	2015	Brazil	National	1970-2010	Ecological Economics	To estimate GPI as an alternative to GDP and draw some policy implications	17	Built & financial: 5; social: 5; natural: 7	Assume 25% of consumption defensive, include public infrastructure and lost NK services, timber depletion	World Bank, Brazilian Institute of Applied Economic Research, Agricultural Research Corporation	User cost for NRR depletion, untreated sewage cost, compensation for future carbon damage	Lost functions and services from NK added into one item, timber instead of lost forest	Not discussed	GPI/GDP ratio was 0.53 in 1970 and 0.44 in 2010, p.c growth rate 1.7% and 2.2%	Ecological Footprint/ Biocapacity,	Points to benefits from poverty reduction, need for increased natural resource use efficiency
20.	Kubiszewski et al. (2015)	2015	US State of Oregon	Sub-national: state	1960-2010	Ecological Economics	To estimate GPI for Oregon, recommend inclusion of a shareholders' report on essential capital assets	26	Built & financial: 8; social: 6; human: 2; natural: 10	Does not indicate, followed methodology by Posner & Costanza (2011)	US Bureaus of Economic Analysis and Labour Statistics, Oregon State Departments, EPA	Damage costs of air pollution, ES loss, replacement cost of NRR, personal pollution abatement	New higher estimates for cost of water and air pollution and ES loss, increasing marginal cost of carbon	Standardise	GPI/GDP ratio remained around 1:2, smaller GPI growth rate until 1970s, after that correlated	Shareholder's Report with balance sheet and liabilities for each type of capital	Potential to highlight components important for progress, account for more welfare components
21.	Hayashi (2015)	2015	Japan (rural and urban)	National and sub-national (urban and rural)	1975-2008	Ecological Economics	To measure rural-urban disparity in Japan using GPI	18	Built & financial: 6; social: 6; human: 2; natural: 4	Use Bleys (2008) and Makino (2008) methods, Atkinson index, omits overwork, unemployment, ozone, noise pollution, NRR, net debt, forest, and wetland loss	Japanese Statistics Bureau Government, Household Surveys, Annual Report of Prefectural Accounts, UN Report on SESA	Industrial water and air pollution, cumulative cost of carbon emissions since 1975	Calculated the value of farmland lost in a single year (not from benchmark), considering paddy and arable land	Localise	Rural/urban GPI were around 0.6-0.7/0.8-0.9 of GDP, grew parallel with GDP until late 1980s, then slowed down/fell	GDP	Can highlight urban/rural progress disparity and its causes, which can be guide policy to address the most pressing issues
22.	Huang et al. (2016)	2016	Chinese cities of Chongqing, Xi'an, Chengdu, Beijing, Guangzhou, Nanjing, Wuhan, Shanghai,	Sub-national: city	1978-2014	Landscape & Urban Planning	To assess the dimensions of sustainability and effects of economic reforms and open-door policies using a range of indicators and	18	Built & financial: 4; social: 6; human: 2; natural: 6	Uses Wen (2008) methods, calculates Gini for urban and rural areas separately, assume zero net forest loss	Cities' Statistical Yearbooks, China's Urbanisation Report 2012 and Statistical Yearbooks, BP Statistical Review of World Energy	Net price method for depletion of NNR, HCA for environmental pollution, access to water and sanitation, air pollution for	Assume zero net forest loss in urban areas, include wastewater treatment, pesticide intensity, biome protection to account for	Not stated	In all cities, GPI/ and GDP/capita showed an upward trend, but GDP grew faster; GPI/GDP ratio fluctuate	Ecological Footprint, Biocapacity, Environmental Performance Index, City Development Index, Human Development Index, Gini	Can complement other indicators in revealing effects of policies on economic welfare, highlighting its different components

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			Shenyang, and Tianjin				compare GDP/GPI ratio over time					environmental health	effects on ecosystems		between 0.1 and 1.1	coefficient, Urban–rural income ratio	
23.	Delang, (2016)	2016	Singapore	National	1968-2014	Green Economics	To estimate GPI for Singapore and compare it to GDP, drawing implications for sustainable economic wellbeing	20	Built & financial: 7; social: 6; natural: 7	Does not indicate methodological innovations	Singapore Department of Statistics, Yearbooks of Statistics, Ministry of Environment and Natural Resources	User cost for NRR and fisheries depletion, cost of land restoration, cumulative cost of climate change and wetland loss	Cumulative cost of climate change based on carbon market value, 7% restoration cost of agricultural output	Not stated	GDP:GPI/capita ratio between 0.3 and 0.9, GDP average growth rate 5.17%, GPI 4.62% until 1999, then decreased	Not stated	According to results, the resources spent on promoting economic growth should be spent on increasing welfare
24.	Talberth & Weisdorf (2017)	2017	US state of Maryland and city of Baltimore	Sub-national: state and city	2012-2014	Ecological Economics	To update, explain and pilot the GPI 2.0 methodology	52	Built & financial: 11; social: 16; human: 5; natural: 20	Replace PCE with HBE, broaden DEFR, HIE, INQ based on diminishing marginal utility of income, expand range of sub-indicators for services from essential capital, omit net capital investment and net foreign debt	US Bureau of Statistics and Labour Statistics, Natural Resource Defence Council, Geological Survey, Department of Agriculture, TEEB, EPA	ES provided by protected areas, costs of land conversion, replacement costs of NRRER, consumption, groundwater depletion and soil erosion	Include ES from protected areas, present value of ES forgone due to land change, loss grasslands, aquifer depletion, soil erosion, pollution from solid waste	Standardise	GPI:GDP ratios is roughly 1:2, in Maryland, GPI growth (3.97%) was faster than GDP growth (0.88%)	Not stated	Can serve as a measure of economic performance that can be compared across regions and nation, as a tool for policy analysis, for identifying optimal scale of economies
25.	Hou (2017)	2017	Liaoning Province, China	Sub-national: province	1978-2011	Social Indicators Research	To apply GPI as an alternative measure of sustainable economic wellbeing and draw policy implications	20	Built & financial: 8; social: 5; human: 1; natural: 6.	No indicated innovations, used Talberth et al. (2007) method, omit 6 components due to data constraints	Liaoning Statistical Yearbook, previous studies	Abatement and health costs of pollution, farmland occupation tax for lost ES, resource tax for NRR depletion, marginal carbon damage costs	Collected solid waste and health costs as proxies for costs of pollution, use taxes as proxy for resource depletion	Not stated	GPI similar level to GDP until 1992, then diverges, to the ratio of 0.28 in 2011, GPI average growth rate 8%, while GDP 15%	GDP	Can help to assess long-term impacts of policies and guide budget and planning decisions

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26.	Held et al. (2018)	2018	Germany and six of its federal states	National and sub-national (federal)	1991-2014	Ecological Economics	To calculate the national and federal state level index of national welfare based on GPI methodology	20	Built & financial: 3; social: 5; human: 2; natural: 10	Omit net capital growth, net change in international trade position, costs of ozone depletion, include costs of nuclear energy	German and Federal Statistical Offices, Governmental Departments and Agencies, previous studies	Replacement cost of NRR based on German renewable energy mix,	Nuclear energy costs based on a cost rate for Germany, new method for NRR depletion based on current production	Standardised GPI 2.0 for comparison and allow local indexes for context-specific analysis	GDP/capita surpassed GPI in 1999, diverging until 2015 when GPI:GDP ratio was 0.8	GDP and locally based indexes	Highlighting the difference between market activity and economic wellbeing, directing policy by considering costs and benefits of growth
27.	Fox & Erickson (2018)	2018	50 states of the US	Sub-national: state	2011	Ecological Economics	To calculate GPI for all 50 US states using consistent methodology and assess its suitability to guide state-level economic policy	25	Built & financial: 7; social: 6; human: 2; natural: 10	Calculates and analyses GPI for 50 states using similar methods, making comparisons	US Bureau of Economic Analysis, Census Bureau, State Departments, National Agriculture Statistics Service, Energy Information Administration, EPA	Damage costs of pollution, costs of net wetland, farmland and forest change, cost of carbon, ozone and NRR depletion	Agricultural production used for farmland change, separate replacement costs for electrical and non-electrical sectors	Standardise	GPI/capita correlated with GSP/capita ($r = 0.51$), but standard deviation of GPI was 58% higher than GSP	GDP and subjective wellbeing polls	Can help to determine the effectiveness of targeted policy measures aimed at improving separate indicators
28.	Brown & Lazarus, (2018)	2018	State of California, US	Sub-national: state	2010-2014	Ecological Indicators	To calculate GPI for California, and compare results to the estimation by Fox (2017), analysing the effects of method and data choices on GPI, supplementing it with HDI	24	Built & financial: 5; social: 7; human: 2; natural: 10	Excludes net foreign borrowing and family breakdown and includes value of state-provided healthcare	US Bureau of Economic Analysis, American Community Survey, Time Use Survey, EPA	Replacement cost of NRR; costs of pollution, changes in wetlands, farmlands, forest, household pollution abatement	Not stated	Standardise but allow localised versions	GPI is around 52% of GSP, in the study period, GSP grew by 9.2% and GPI by 9.8%.	Human Development Index, Planetary Boundaries, health of critical ecosystems, metrics for subjective and spiritual well-being, inequality across groups	As an aggregate and comprehensive welfare indicator, can be used for assessing the overall impact of specific proposed policies
29.	Huang (2018)	2018	10 cities in China: Chengdu, Chongqing, Xi'an, Wuhan, Beijing,	Sub-national: mega city	1978-2015	Sustainability	To compare the weak (GPI) and strong sustainability indicator results for China's 10 mega-cities	19	Built and financial: 4; social: 7; human: 1; natural: 7	Same as Huang (2016), complement GPI with EF as weak and strong sustainability indicators, also inequality	Cities and China Statistical Yearbooks on Energy, Environment, Urbanization Report, BP Review of World	Net price method for depletion of NNR, HCA for environmental pollution, access to	Assume zero net forest loss in urban areas, include wastewater treatment, pesticide	Not stated, but applies local approach	Decreasing GPI/GDP ratio up to 2005, then stabilising and ranging from 14.6%	Ecological Footprint, Happy Planet Index, Critical Natural Capital	Combined with least one strong sustainability indicator, e.g., GPI/EF ratio, can help cover

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			Guangzhou, Nanjing, Shanghai, Tianjin, Shenyang							adjustment for urban areas different from rural	Energy, Institute of Geographic Sciences and Natural Resources	water and sanitation, air pollution costs	intensity, bi-ome protection to for effects on ecosystems		(Tianjin) to 52.7% (Chongqing)		all sustainability dimensions
30.	Patterson et al., (2019)	2019	New Zealand	National	1970-2019	Massey University	To calculate GPI for New Zealand as an alternative to GDP	21	Built & financial: 2; social: 7; human: 2; natural: 10	Adds voluntary and household work together, biological pests and loss of some ES, does not include NRR depletion, use 1970 benchmarks for ES loss	Statistics New Zealand, Land Resource Database, Department of Conservation, government agencies, TEEB Valuation database, OECD, previous studies	Harvested indigenous forest x price per ha, cost of pest damage and control, cumulative costs of lost wetlands, lost soil ES due to urbanisation	Used 1970 benchmark, from which calculate cumulative costs of ES loss, elaborate methods for pollution costs, omit NRR depletion	Not stated	GDP grew by 91% over the study period from 1970 to 2016, while GPI grew only by 53% over the same period.	Ecological Footprint and Genuine Savings Index	To use "GPI dashboard" showing the development of GPI sub-indicators over time to address those components causing welfare losses
31.	Kenny et al. (2019)	2019	Australia	National	1961-2013	Ecological Economics	To revisit Australia's GPI, comparing alternative methods and assessing impacts on the results	21	Built & financial: 5; social: 5; human: 4; natural: 7	Use Kubiszewski et al (2015) methods, with some marked differences in calculation of sub-indicators adapted to the Australian context	Australian Bureau of Statistics, National Pollutant Inventory of Australia	Lost farmland and forest, replacement cost of NRR, cost of water pollution, mostly non-market valuation and damage functions	Omits costs of wetland and forest cover change, noise pollution, subtract percentage of "unclean" water for cost of water pollution	Standardise "core" components and data but leave space for local nuance	GPI to GDP per capita ratio ranges from 0.9 in 1962 to 0.55 in 2013	GDP	Can inform decisions where to put resources, if standardized, could integrate wellbeing into decision-making and complement GDP
32.	Long & Ji (2019)	2019	China's 31 mainland provinces	National and subnational (province)	1997-2016	Ecological Economics	To assess the "quality" of economic growth in 31 of the China's mainland provinces by applying GPI methodology	25	Built and financial: 6; social: 9; human: 2; natural: 8	Use Atkinson inequality index, add cost of solid waste pollution and cost of natural disasters, omit net international debt, cost of noise pollution, farmland loss, and ozone depletion	China Statistics Yearbooks, provincial statistics yearbooks	Costs of pollution, changes in wetlands and forests, costs of natural disasters, fuel tax approach to costs of long-term environmental damage	Cumulative costs of carbon emissions, escalating NRR replacement costs, costs of natural disasters	Not stated	GPI is lower than GDP in almost all provinces almost all the years, and while both rise, the gap is generally widening	GDP	Offers insights into social welfare, account for environmental and social costs and concrete policy suggestions for provinces based on GPI component analysis

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33.	Hashim et al. (2019)	2019	South Korea and Malaysia	National	1980-2014	Cleaner Production	To assesses the effects of two approaches to dealing with the Asian economic crisis of the 1990s - IMF debt and capital control - on GDP and GPI in South Korea and Malaysia	12	Built & financial: 8; social: 2; natural: 2	None stated, omitted many components due to data constraints	UN, World Bank, national statistical offices of Korea and Malaysia, OECD	Cost of air pollution and adjusted savings for natural resource deletion	Assume air pollution cost at 0.25% of HCE, use adjusted savings data from World Bank	Not stated	In South Korea, the difference between GDP and GPI per capita grew 1600%, in Malaysia by 300%, GPI/GDP ratio between 0.3 and 0.7	Not stated	Can inform handling future crises from economic wellbeing perspective: external debt contributes positively to GDP/ GPI, capital control does not
34.	Pais et al. (2019)	2019	The 28 OECD countries	Multi-national (28 OECD countries)	1995-2015	Energy Economics and Policy	To calculate a comparable GPI for the 28 OECD countries, comparing it between them and with GDP performance	11	Built & financial: 7; social: 1; natural: 3	Group some components into non-defensive and rehabilitative public expenditure, services provided by public infrastructure, and unpaid work, omit many indicators, use comparable data for OECD countries	OECD, World Bank, Standardized World Income Inequality Database, International Energy Agency	Cost of air pollution using marginal cost estimates, substitution cost for NRR, and marginal social cost of carbon	None stated	Standardise	Big divergencies between GPI and GDP in all countries, except Italy and UK, highest gaps in Latvia, Luxembourg and Estonia, gaps reduced after 2009, GPI<GDP in all countries	GDP	Provide information to policy makers seeking to achieve economic growth and SD, can benchmark performance of comparable countries to search for effective policy interventions
35.	Guan et al. (2021)	2021	China	National and sub-national (province)	2016	Sustainable Production & Consumption	To measure national and province level sustainable development in China using GPI, for which an extensive survey was conducted in 42,000 households	23	Built & financial: 6; social: 6; human: 3; natural: 8	Data for 14 components collected through a micro-household level survey, add food and energy waste, dust and fog prevention, and furniture repair and maintenance expenditures	Micro-survey data, Chinese National Bureau of Statistics, Statistical Yearbook, Statistical Yearbook on Environment	Costs of pollution, lost farmland x agricultural production per acre, replacement cost of NRR, KN services via benefit transfer for regulating and maintenance and cultural ES	Include cost of solid waste pollution and dust and fog protection, regulating and maintenance and cultural ES values via benefit transfer, omit wetland and forest loss	Not stated	GPI smaller than GDP in all provinces, ranging from 27% to 60%, GPI/GDP ratio for China in 2016 was 47%	Not stated	Tool for evaluating SD performance nationally/regionally and promoting economic welfare, disparities between regions point to a need for differentiated policies

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36.	Cook & Davíðsdóttir (2021)	2021	Iceland	National	2000-2019	Ecological Economics	To estimate GPI for Iceland using GPI 2.0 methodology	38	Built & financial: 13; social: 9; human: 7; natural: 9	Uses GPI 2.0 method by Talberth & Weisdorf (2017), include ES values, omit internet services, household work, water, noise pollution, underemployment, pollution abatement and soil erosion	Statistics Iceland, OECD, UN, government agencies, previous studies	Services from NK, replacement cost of NRR depletion, fisheries over-harvesting, avoided damages by pollution abatement costs of pollution, ozone depletion	Inclusion of NK service values via benefit transfer, include avoided depletion and damages	Not stated	GPI was between 2.41 and 3.05 times the value of national GDP	Not stated	Outcomes can raise awareness of the costs and benefits of economic strategies and highlight a need for corrective action where the largest costs occur
37.	Senna & Serra (2021)	2021	Brazilian state of Rio de Janeiro	Sub-national: state	2002-2016	Environment, Development, and Sustainability	To estimate GPI for the state of Rio and highlight the areas where targeted policies could make the most difference in improving GPI	35	Built & financial: 10; social: 10; human: 4; natural: 11	Use Talberth & Weisdorf (2017) GPI 2.0 method with some adjustments due to geographical and biological context, omit some components to avoid double counting	Brazilian Statistics Institute; Rio de Janeiro State Statistics Agency, previous studies	ES from protected natural capital estimate; replacement costs of NRR and groundwater depletion, productivity loss from soil erosion, costs of pollution	ES from protected natural capital based on benefit transfer from Costanza et al. (2014)	Not stated	GPI/GDP ratio between 0.22 and 0.31 in the study period, with average growth rates of 7.95% and 9.30%, respectively		Results call for policies on variables that affect GPI most negatively: unemployment, renewable energy, public transport, service from protected KN
38.	Lazarus & Brown (2022)	2022	US and the state of California	National and sub-national (state)	1995-2017	Ecological Economics	To calculate GPI for US and California using different methods with and without historical thresholds for NK, addressing some of the common criticisms of GPI	25	Built & financial: 6; social: 7; human: 2; natural: 10	Alternative accounting methods for the five components that use benchmarking (inequality; leisure time; farmland; forests; and wetlands), use average wage household work, leisure time and voluntary work	US Bureaus of Economic Analysis and Labour Statistics; American Time Use Survey; Government and California State Departments, Forest Service; EPA, Public Policy Institute of California; WHO, UNEP	Change in acreage of forests, wetlands and farmlands multiplied by the value of ES for 50 years with a 3% discount rate, cost of pollution, climate change (marginal carbon cost)	Calculate change in KN services per year instead of local historical benchmarks for wetland, forest, and farmland,	Standardise	Removing benchmarks resulted in much higher GPI values and GPI/GDP ratio: from 0.1-0.5 to 0.8-1.1	GDP	Tool to measure progress, determine effects of policies on different components, compare progress of different entities, measure costs and benefits of economic activity

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39.	Karato-pouzis et al. (2022)	2022	Australia	National	2019-2020	Ecological Indicators	To compare GDP and GPI before and after the start of COVID-19 pandemic, drawing some insights on the relationship between them and the extent to which GPI can be used as an indicator of economic wellbeing	21	Built & financial: 7; social: 7; human: 2; natural: 5	Short study periods; exclude costs of noise pollution, wetland change, personal pollution abatement, forest coverage changes and services of roads, 2 scenarios with different values of leisure time.	Australian Bureau of Statistics, Australian Government, previous studies	Cost of air pollution, climate change, farmland change, NRE and ozone depletion using estimated by Kenny et al (2019) and O'Mahony et al (2018)	Not stated	Standardise	Scenario 1 (high leisure time value) in Q1, GPI growth was positively related to GDP growth but negatively in Q2, Scenario 2 (low leisure time value) – positively related to GDP in both Qs	A set of indicators, such as Measures of Australia's Progress 'dashboard' including education levels, population health, community wellbeing, bio-physical indicators	Can help raise stakeholder awareness of trade-offs between their choices, which makes it a more useful method for measuring national progress and well-being centred decision making
40.	Li et al. (2022)	2022	Yangtze River Delta, China	Sub-national: river delta	2000-2018	Environmental Science and Pollution Research	To evaluate the ecological efficiency and economic sustainability of the Yangtze River Delta using GPI, EF, examine spatial autocorrelation between GPI, GDP and EF	17	Built & financial: 4; social: 7; human: 1; natural: 6	Gini calculated separately for rural and urban areas, omit net foreign debt,	Statistical Yearbooks of cities, China Environmental Statistics Yearbooks, Institute of Geographical Sciences and Natural Resources, Chinese Academy of Sciences	Environmental treatment costs for pollution, loss of wetland and forest ES benefit transfer from Costanza et al. (1997), net price method for NRR depletion	Own estimation of value of lost farmland	Not stated	GPI/GDP showed a downward trend and gradually stabilised, fluctuated between 0.2 and 0.5	Ecological Footprint, GDP, and their ratios to GPI	Point to need to strengthen green technological innovations, reduce natural-resource dependence of growth, stronger environmental regulations
41.	Van der Slycken & Bleys (2023)	2023	Belgium, Europe	National	1995-2018	Social Indicators Research	To develop a dual GPI methodology that deals with cross-time and boundary complexities related to Fisherian and Hicksian notions of income and apply it to the case study of Belgium,	16	Built & financial: 9; social: 1; natural: 6	Calculates two variants of GPI based in Fisherian and Hicksian income, sufficiency threshold for consumption expenditure, accounts for emissions embodied in trade, includes aviation,	Eurostat, OECD, World Bank, UN, EU, EC, AMECO, European Environmental Agency (EEA), previous studies	GPI.bce includes current ecological costs experienced within borders, while GPI.bcpa includes capital changes and ecological costs shifted in time and space, costs of	Add costs of N pollution, extreme weather events, nuclear power, emissions embodied in trade, the climate impacts of aviation and shipping, transition	Not stated	GPI.bcpa is lower than GDP through the entire period, while GPI.bce is higher than GDP 1995-2004 and 2009-2013, GDP/capita grew by 30%, GPI.bce	GDP	Can account for shifts ecological costs in time and better inform policymakers about adverse effects of economic activities, help to address the environmental costs that are

Number	Reference	Year published	Location	Scale	Years covered	Journal/ outlet	Motivation	Number of indicators	Indicators/type of capital	Stated method innovations	Common data sources	Main KN accounting methods	Stated KN method innovations	Standardised vs. local approach	Relation to GDP	Supplement with other indicators?	Stated policy implications
							demonstrating the effects			shipping, and shadow economy		pollution, nuclear power, carbon	costs from NRER		by 15%, GPI.bcpa by 18%		outsourced to other regions and timescales
42.	Guan et al. (2024)	2023	China	National and sub-national (province)	1979-2018	Social Indicators Research	To measure the quality of economic development in 29 provinces of China and causality between carbon emissions and GPI and GDP	28	Built & financial: 9; social: 7; human: 5; natural: 7	Use similar method as Guan et al (2021), include value of services from KN, manufacturing and infrastructure, add solid waste pollution	China and Provincial Statistical Yearbooks, China Carbon Price Survey	Cost of pollution, KN services, replacement cost of NRR, cost of GHG emissions	Include solid waste and services from natural capital	Not stated	GPI smaller than GDP in all provinces, ranging from 27% to 60% of GDP, GPI/GDP ratio for China in 2016 was 47%	Carbon emissions, GDP	GPI maximising can be used as a policy goal – to maximise economic welfare
43.	Van der Slycken & Bleys (2024)	2024	EU-15	Multi-national (EU-15)	1995-2018	Ecological Economics	To calculate welfare measured by GPI for EU-15 countries by applying two methods	16	Built & financial: 9; social: 1; natural: 6	Considering costs and benefits of economic activity across time and space boundaries	Eurostat, National Accounts, OECD, World Bank, UN, EU, AMECO, EEA, previous studies	Same as Van Slycken & Bleys (2023)	Same as Van Slycken & Bleys (2023)	Not stated	GPI.bce/GDP ratio was 0.75-1.05, GPI.bcpa/GDP ratio 0.65-0.8, GDP/capita grew by 32.4% while GPI by 10.5% and 13.4%, respectively	GDP	Accounting for costs shifted in space point to benefits of green economic transition, stricter environmental policies and need for greening capital stock