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Modelling and measuring sustainable wellbeing in connection with the UN Sustainable Development Goals

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ABSTRACT

The UN Sustainable Development Goals (SDGs) offer a detailed dashboard of goals, targets and indicators. In this paper we investigate alternative methods to relate the SDGs to overall measures of sustainable wellbeing that can motivate and guide the process of global societal change. We describe what a Sustainable Wellbeing Index (SWI) that connects with and complements the SDG dashboard might look like. We first investigate several options for how to construct such an index and then discuss what is needed to build consensus around it. Finally, we propose linking the SDGs and our SWI with a comprehensive systems dynamics model that can track stocks and flows and make projections into the future under different policy scenarios.

1. Introduction

The Sustainable Development Goals (SDGs) agreed in the UN 2030 Agenda for Sustainable Development (UN, 2015) are a major step forward and an improvement on the Millennium Development Goals (MDGs). They address some of the systemic barriers to sustainable development and contain better coverage of, and balance between, the three dimensions of sustainable development – social, economic, and environmental – and their institutional/governance aspects. In addition, the SDGs apply to all countries, not just developing nations, as the MDGs did. The SDG process provides an opportunity to trigger systemic change to build a sustainable future in an increasingly interconnected world, However, with 17 goals, 169 targets, and over 300 indicators proposed, the SDGs provide diluted guidance at best. This is to be expected, given the complex political process that led to the SDGs.

The SDG process so far has merely opened the door. There is still much additional work needed to elaborate (1) the complex interconnections between the goals; (2) the means-ends continuum toward an overarching goal; and (3) a 'narrative of change' to describe the societal shifts and policy reforms necessary to achieve the SDGs and how this could actually happen within existing socioeconomic and geopolitical circumstances (Costanza, 2014; Ostrom, 2014).

The SDGs need an overarching goal with clear metrics of progress toward that goal that are geared to integrate the sub-goals (Costanza et al., 2014a). Fig. 1 shows the relationship between the "ultimate end" of sustainable, equitable and prosperous wellbeing and the intermediate means of the economy and society, and the ultimate means of the environment. Table 1 shows the 17 proposed SDGs clustered according to the three sub-goals of ecological economics originally proposed by Daly (1992) of sustainable scale, fair distribution, and efficient allocation. These are embedded in the "means-ends" spectrum shown in Fig. 1.

One important point of clarification is that sustainability is impossible to measure directly. It can only be assessed after the fact, so any measure of "sustainability" is in reality a prediction of which characteristics of the system might ultimately be sustainable (Costanza and Patten, 1995; Garnåsjordet et al., 2012). The requirement for "sustainable

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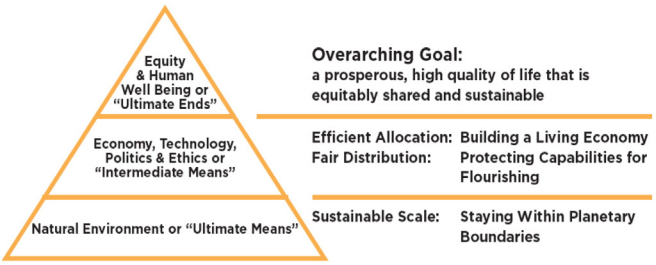

Fig. 1. The "means – ends" spectrum showing the three elements of sustainable wellbeing used to cluster the SDGs in Table 1 (Costanza et al., 2014a).

scale" is based on the idea that a sustainable system cannot deplete natural capital or damage ecosystem services beyond a certain "safe operating space" (Rockström et al., 2009). What we are after is a system that is both sustainable and desirable in all senses, including the contributions of natural, social, human, and built capital assets (Costanza et al., 2013). Ultimately, to properly assess sustainability and desirability will require an integrated dynamic systems modelling approach, as we discuss further on. The SDGs represent an important step in building global consensus on what kind of world is desirable, and sustainability in the sense of longevity is certainly one of the characteristics of a desirable world, but it can only be predicted, not measured directly.

In this paper, we investigate alternative methods to relate the SDGs to overall measures of sustainable wellbeing that can motivate and guide the process of global societal change. The SDGs, along with their targets and indicators provide a detailed dashboard for the transition to sustainable development. Some would argue that a dashboard approach is sufficient and the only feasible option. We disagree and contend that dashboards and aggregate indicators are *not* mutually exclusive — in fact they are both essential. For example, having a well-instrumented dashboard in your car is essential, but so is knowing where you are going and whether you are making progress toward your destination. As baseball star Yogi Berra once quipped: "if you don't know where you're going, you end up somewhere else." We must first decide where we are going - our overarching goal - in order to measure progress toward it. The 17 proposed SDGs are best seen as sub-goals or means to this larger end (Table 1). We are certainly not recommending throwing out the dashboard, but merely recognizing that the dashboard and an aggregated indicator of overall progress toward our shared goal are *both* necessary if we hope to achieve our goal.

The SDGs in fact acknowledge this need in Target 17.19, which states: "By 2030, build on existing initiatives to develop measurements of progress on sustainable development that complement gross domestic product, and support statistical capacity-building in developing countries."

In this paper we investigate what an aggregate Sustainable Wellbeing Index (SWI) that connects with the SDG dashboard might look like. We first analyse several options for how to construct such an index and then propose a way forward that builds a hybrid approach. Finally, we propose linking the SDGs and our SWI to a comprehensive, non-linear, systems dynamics model that can track both flows and stocks of built, human, social, and natural capital and make projections into the future under different policy scenarios. This is an essential and often overlooked step in the process. GDP has been so widely accepted partly because of its links to the System of National Accounts (SNA) and the underlying static, linear input-output model of the economy. We need a new, integrated, dynamic systems model to underlie and integrate the SDG goals and aggregate wellbeing indicators.

Table 1
the 17 SDGs (UN, 2015) clustered under the three elements of sustainable wellbeing shown in Fig. 1.

Efficient allocation: building a living economy	
Goal 7.	Ensure access to affordable, reliable, sustainable, and modern energy for all
Goal 8.	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
Goal 9.	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
Goal 11.	Make cities and human settlements inclusive, safe, resilient and sustainable
Goal 12.	Ensure sustainable consumption and production patterns
Fair distribution: protecting capabilities for flourishing	
Goal 1.	End poverty in all its forms everywhere
Goal 2.	End hunger, achieve food security and improved nutrition, and promote sustainable agriculture
Goal 3.	Ensure healthy lives and promote well-being for all at all ages
Goal 4.	Ensure inclusive and equitable quality education and promote life-long learning opportunities for all
Goal 5.	Achieve gender equality and empower all women and girls
Goal 10.	Reduce inequality within and among countries
Goal 16.	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
Goal 17.	Strengthen the means of implementation and revitalize the global partnership for sustainable development
Sustainable scale: staying within planetary boundaries	
Goal 6.	Ensure availability and sustainable management of water and sanitation for all
Goal 13.	Take urgent action to combat climate change and its impacts *
Goal 14.	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
Goal 15.	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

2. Existing General Approaches

There have been a large number of alternative approaches to aggregate indicators of societal wellbeing and progress developed over the years. Costanza et al., 2014b includes a table listing some of the major ones. Three basic approaches have been used in developing these indicators. We first discuss these basic approaches and then discuss how these approaches might be applied to the SDGs.

1. Consumption, Production, and Wealth Based Indicators
   Conventional measures of national progress, like the gross domestic product (GDP), are based on production and consumption of goods and services exchanged in markets (with the odd imputed value). GDP was never designed as a measure of societal wellbeing, but a popular assumption, derived from utilitarian philosophy, is that, all else being equal, more consumption leads to higher wellbeing and that therefore GDP/capita can be used as a proxy for national wellbeing (Costanza et al., 2014d). This assumption has been challenged for decades and the problems with using GDP as an indicator of national wellbeing are well known (Stiglitz et al., 2009; Fioramonti, 2013; Fleurbaey and Blanchet, 2013; Costanza et al., 2014b). For example, UNDP (1996) identified five types of negative GDP growth: (1) *jobless growth* (the economy gets bigger with more buying and selling of goods and services, but without creating more jobs); (2) *voiceless growth* (an apparently successful economy rides on the back of the suppression of civil rights, union membership and democracy); (3) *ruthless growth* (accompanying high or rising inequality); (4) *rootless growth* (culturally destructive effects of economic globalisation); and (5) *futureless growth* (that steals our collective future by depending on the unsustainable consumption of finite natural resources).
   Several alternatives have been devised that attempt to correct some of the problems with GDP. These include Green GDP (Boyd, 2007; Li and Lang, 2010), Genuine Savings (Hamilton and Clemens, 1999; Pillarisetti, 2005), the Inclusive Wealth Index (UNU-IHDP and UNEP, 2014), the "degrowth accounts" proposed by O'Neill (2015), and the Index of Sustainable Economic Welfare (ISEW – Daly and Cobb, 1989), also known as the Genuine Progress Indicator (GPI – Talberth et al., 2007). For example, the GPI is calculated by starting

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with personal consumption expenditures, a measure of all spending by individuals and a major component of GDP, weighting it by income distribution to recognize the impacts of inequality on societal welfare (Wilkinson and Pickett, 2009), and making more than 20 additions and subtractions to account for 'goods' and 'bads' which are not included in conventional measures of income. "Goods" include volunteer work and work in the family, and "bads" include costs of divorce, crime, pollution and the depletion of natural capital. The GPI has been estimated for several countries and has been formally adopted by the US States of Maryland and Vermont. Results show that when growing inequality and environmental costs are incorporated, GPI has not been growing at all in many countries over the last several decades (Kubiszewski et al., 2013).

The SDGs include some costs and benefits not incorporated in the GPI, for example gender equality, urban resilience, and accountable institutions. One could create a "GPI SDG" that incorporated these factors as well as other changes that have been suggested. One characteristic of GPI is that it is denominated in monetary units, making it directly comparable with GDP but also requiring that all the elements be assessed in monetary units. These valuations can be quite difficult and imprecise. But one should keep in mind that GDP itself, and the data behind it, is not as precise as often assumed, especially for developing countries (Fioramonti, 2013, 2014).

2. Aggregation of all of the SDG Indicators Into a Unit-Less Index
One could build an aggregate, unit-less indicator from the expected 200–300 SDG indicators. The well-known problem with this approach is how to weight the different indicators. There are several examples of this approach (Costanza et al., 2014b). One recent example is the OECD Better Life index (http://www.oecdbetterlifeindex.org/), which is built from 11 elements, each with one or two indicators. In the default mode, each element is ranked on a 1–10 scale and the elements are averaged together, weighted equally. However, one can change the weights on the website and observe the effects on the rankings. The OECD is collecting a survey of user weightings and this could be used to construct a weighted index. But weighting all the SDG indicators via surveys seems too ambitious and a simple unweighted average seems arbitrary and not in line with different national priorities. Furthermore, for many of the SDGs and associated goals and indicators, data will not be available for all countries in the short and medium term. Similar concerns can be raised with respect to new indices such as the Social Progress Index (recently adopted in Massachusetts and in Paraguay) and the Legatum Prosperity Index, which aggregate various dimensions of wellbeing, social capital and prosperity.
3. Contributions to Subjective Wellbeing
Another approach to weighting is to construct a regression model with all indicators as the independent variables and some existing approximation of wellbeing – for example subjective life satisfaction scores – as the dependent variable. This would provide statistically derived weights in terms of degree of correlation with the dependent variable. The main challenge here is what to choose as the dependent variable. Subjective wellbeing (SWB), from international/national public opinion surveys, has been suggested by some as the most appropriate dependent variable and the most appropriate national policy goal (Layard, 2005). There has been some research with statistical models that include subjective wellbeing as the dependent variable and built, human, natural and social capital indicators as the independent variables (Vemuri and Costanza, 2006; Abdallah et al., 2008). These approaches successfully predict over 80% of the variation in subjective wellbeing across countries. More recently, the World Happiness Report (Helliwell et al., 2016) developed regressions of SWB against a range of independent variables that explained 73% of the variation across countries.

However, it is also well known that individuals' perceptions are limited, they may be culturally biased, and people may be unaware of some of the factors that contribute to their wellbeing (Kahneman, 2011). For example, the contributions of natural capital and ecosystem services may not be well perceived by individuals and may not show up in life satisfaction surveys. Individuals do not directly perceive the climate regulation benefits of forests or the storm protection benefits of coastal wetlands, although these may be critical contributors to their sustainable wellbeing. Moreover, measures of subjective wellbeing can be heavily influenced by cultural factors making international comparisons difficult. For example, studies comparing levels of happiness and depression in China and the United States showed that, although the Chinese seem less happy (Spencer-Rodgers et al., 2004) and optimistic (Lee and Seligman, 1997) than their American counterparts, people living in the US are more depressed than the Chinese (Demyttenaere et al., 2004).

3. A Hybrid Approach

All of the approaches mentioned above have positive and negative aspects. So the question becomes: can we construct a hybrid indicator that incorporates most of the positive aspects and minimizes the negative? As Costanza et al. (2014b) conclude:

"The successor to GDP should be a new set of metrics that integrates current knowledge of how ecology, economics, psychology and sociology collectively contribute to establishing and measuring sustainable wellbeing. The new metrics must garner broad support from stakeholders in the coming conclaves."

Against this backdrop, one potential hybrid SWI could be a combination of three basic parts, each covering the contributions to sustainable wellbeing from the dimensions of economy, society, and nature.

a - Net Economic Contribution: E
The GPI can be thought of as a measure of the *net* contribution of economic (production and consumption) elements to wellbeing. As we have seen, it weights personal consumption by income distribution, adds some positive economic elements left out of GDP, and subtracts a range of costs that should not be counted as benefits. Although some costs to natural and social capital are included in GPI, many others are missing (e.g. loss of community cohesion due to the social disruptions caused by economic growth) and we also need a way to measure and include the positive benefits to wellbeing from natural and social capital. We therefore need to supplement the current GPI with additional cost estimates from the SDGs, including its targets and proposed indicators, as well as measurements of the positive contributions of natural and social capital.

b - Natural Capital/Ecosystem Services Contribution: N
The positive contributions of natural capital and the ecosystem services it provides have been estimated in spatially explicit form and can be valued in different units, including monetary units (Costanza et al., 1997, 2014c; Sutton and Costanza, 2002). These can be estimated at the country level, as well as at subnational and regional scales and included. For example, the Wealth Accounting and Valuation of Ecosystem Services (WAVES) project of the World Bank (https://www.wavespartnership.org/) is actively pursuing this agenda, as are several other initiative, including the new Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES - http://www.ipbes.net/), The Economics of Ecosystems and Bioversity (TEEB - http://www.teebweb.org/), the Economics of Land Degradation initiative (ELD - http://eld-initiative.org/) and the Ecosystem Services Partnership (ESP - http://www.fsd.nl/esp).

c - Social Capital/Community Contribution: S
The positive contributions to wellbeing from social capital could be captured via surveys of the various components of life satisfaction. For example the World Values Survey as well as regional barometers (e.g. Eurobarometer, Afrobarometer, etc.) ask questions about trust, and other aspects of social capital. However, we may

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need to add additional survey questions that ask explicitly about the value of community and social capital, in addition to individual life satisfaction.

Fig. 2 shows the 17 SDGs and how they contribute to each of the three categories mentioned above. These categories correspond to the three basic goals outlined in the framework of *Ecological Economics* (Daly, 1990; Costanza, 1991; Costanza et al., 2013, 2014e) and the three basic components of sustainability. Note that many of the SDG sub-goals contribute to more than one category.

Ultimately, a pluralistic approach that allows several options to be investigated will be required in the short term, and a consensus-building process will be needed to narrow down the possibilities to those that are most useful in assessing overall progress toward sustainable wellbeing.

But for a start, we propose the following:

$$SWI = f\ (E, N, S) \tag{1}$$

Where: SWI = Sustainable Wellbeing Index
E = Net Economic Contribution
N = Natural Capital/Ecosystem Services Contribution
S = Social Capital/Community Contribution

How these three elements combine to produce SWI is important. They are not linear combinations, since the absence of any one of these factors would lead to zero SWI. At the same time, they are not purely multiplicative with the possibility for infinite SWI. For example, it is clear that increases in material standards make a very major difference to wellbeing in poorer countries where many people lack basic necessities, yet as countries get richer, further increases in material standards make less and less difference to wellbeing. In richer countries social capital and community may be the limiting factor. We therefore propose that a "limiting factor" approach might be a better option. For example an equation like the following might work.

$$SWI = L_{max} * (E/(k_e + E)) * (N/(k_n + N)) * (S/(k_s + S)) \tag{2}$$

Where: L_{max} = the maximum achievable SWI when all factors are simultaneously at their maximum.
k_e = the "half saturation constant" of E – the value of E where the result of this term achieves 1/2 its maximum value.
k_n = the "half saturation constant" of N.
k_s = the "half saturation constant" of S.

In this equation, each of the terms approaches 1 as the variable approaches infinity. As all the terms approach 1, SWI approaches L_{max}. Lmax can be denominated in any relevant units, the simplest being a unit-less maximum on a 0 to 100 or 0 to 10 scale, similar to the subjective well-being scales.

The larger the half saturation constant relative to the size of the variable, the slower is the approach to 1. Any one of the variables can be the "limiting factor." For example, if E is very large its term in the equation will be close to 1. But if S is small its term will be a small fraction that will reduce and limit SWI. Fig. 3 is an example of the relationship for $(E / ((k_e + E))$.

This approach is based on the idea that the best system is one that achieves the overarching goal of a *simultaneously* prosperous, high quality of life that is equitably shared and sustainable (Fig. 1). The goal is not infinite growth, but *balanced* prosperity, equity and sustainability.

Many countries have words that encapsulate this overarching goal as the essence of the "good life". For example, the Swedish term "lagom," means roughly "just the right amount, equitably shared" (Costanza, 2015). In parts of Latin America, this concept is encapsulated in terms such as "buen vivir" and "pura vida", while in Africa it connects with collective welfare traditions like "ubuntu". We are searching for a way to quantify and guide progress toward the goals that many cultures implicitly share.

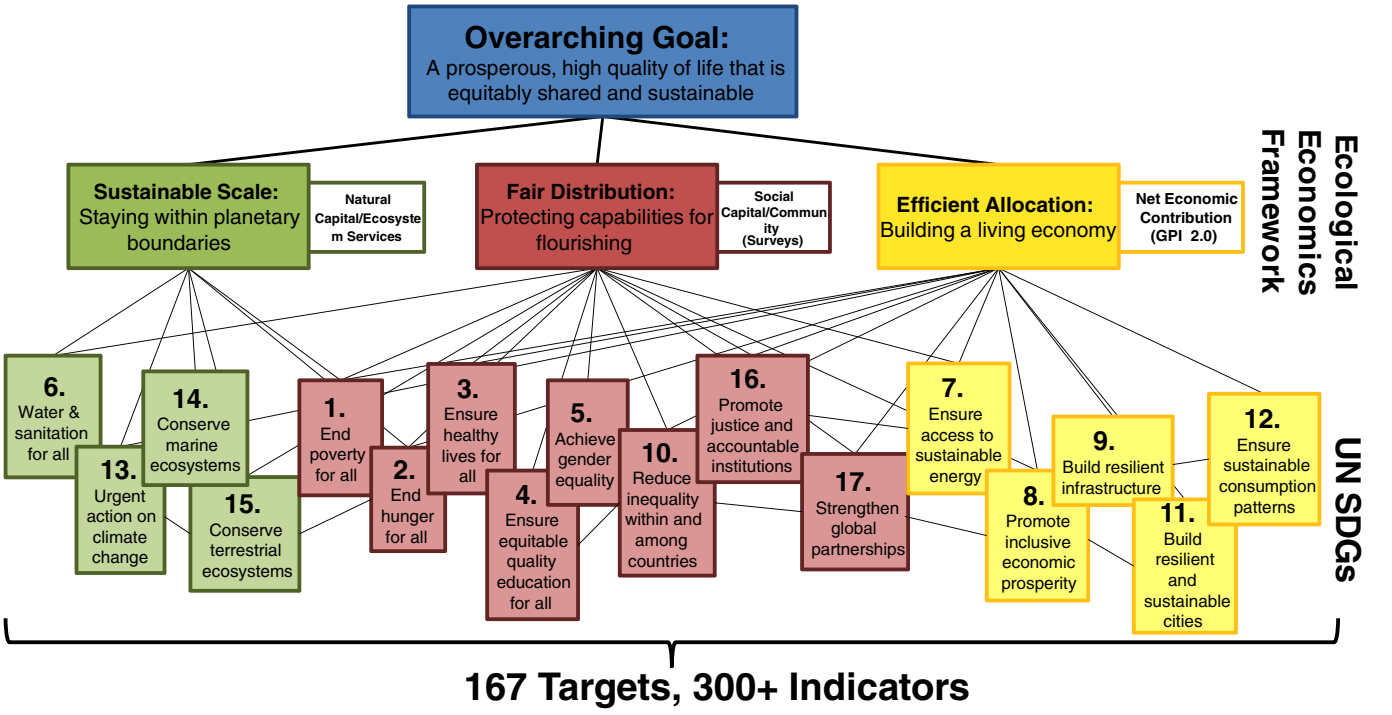

Fig. 2. The relationship of the 17 UN Sustainable Development Goals (SDGs) to each other, to the framework of ecological economics, and to the overarching goal of a sustainable, equitable and prosperous system of humans embedded in the rest of nature.

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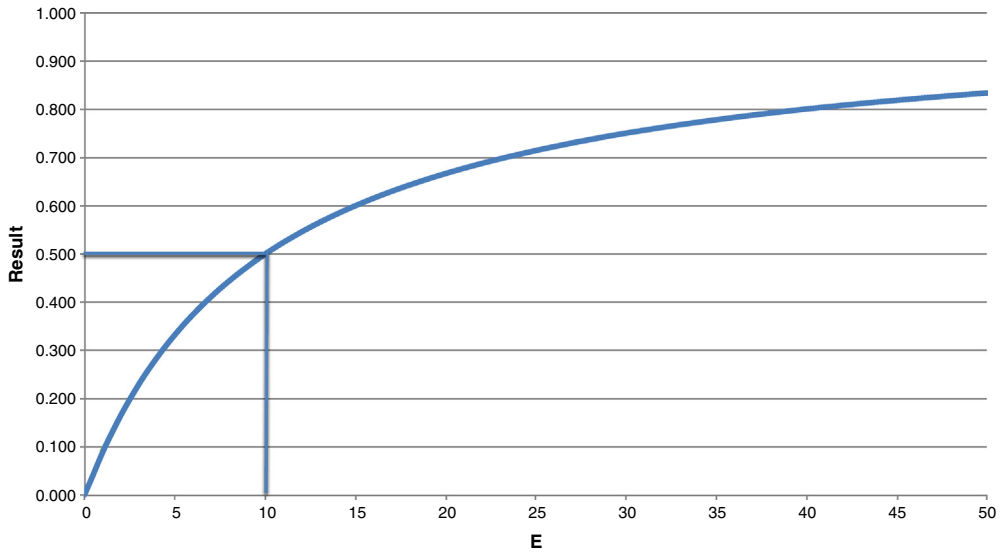

Fig. 3. Example of limiting factor type curve, where: Result = E / (k_e + E) for a value of k_e = 10. k_e is the "half saturation constant" or the value of E where Result reaches 50% of its maximum value.

4. Comprehensive Systems Dynamics Model

One of the reasons why GDP has achieved such dominance as an indicator of national progress is that it is integrated with an underlying model of the economic system. The model used is the basic linear Input-Output originally developed by Leontief (1941). It is a linear accounting model of flows from sector to sector in the economy and to "final demand" (which is GDP). It does not account for stocks of capital assets except as a flow of "net capital formation" that is part of final demand. It is the basis of the System of National Accounts (SNA) that all countries currently use.

We need to replace the misuse of GDP as a measure of national success with not just an alternative indicator of wellbeing, but also with a dynamic, non-linear, systems model of the entire system of the economy-in-society-in-nature that keeps track of both stocks and flows. Fig. 4 is a simplified example. The input-output structure of the economy could be embedded in this model, but it would have to go far beyond that in order to account for the costs and benefits from natural and social capital and the dynamics of capital formation and decline. Versions of such models exist (Boumans et al., 2002; Costanza et al., 2007) and are currently in further development. This approach could help to build better assessments of progress toward sustainable wellbeing. These models can also span several time scales, including past, present, and future scenarios, allowing us to make better predictions of what sets of policies are actually sustainable and desirable and overcome the short-termism that afflicts much of current policy.

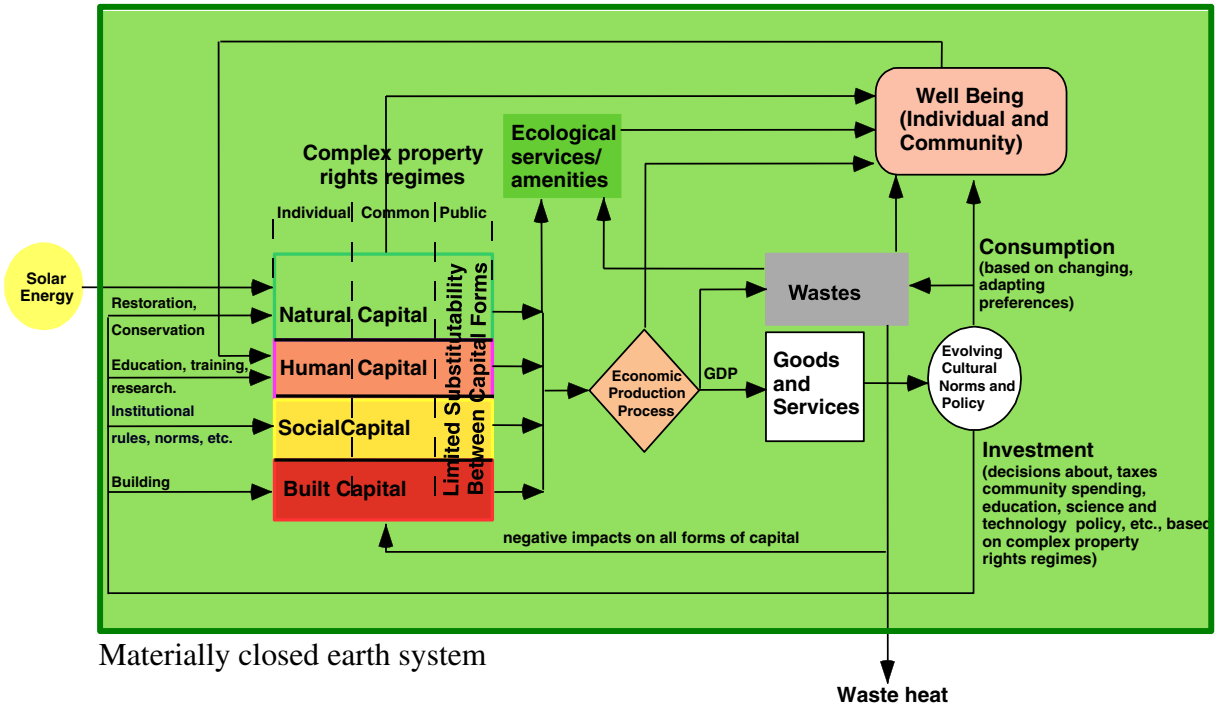

Fig. 4. "Full World" model of the whole system (Costanza et al., 2014e).

5. Conclusions

The agreed UN SDGs are a major achievement in the development of shared goals for all of humanity. The SDGs have been agreed to by all UN member states and they include economic, social, and environmental elements. However, they lack an overarching goal and an effective aggregate indicator of progress toward that goal. One could argue that such an aggregate indicator is not necessary (or possible) and that the pursuit of the individual goals will be sufficient to achieve sustainable development. That might be true if the goals were independent of each other and they all contributed to the overarching goal equally. This is obviously not the case, especially in the context of the widely different situations in each country. We need an aggregate indicator that can assess the relative contribution of each of the SDGs and their interactions with each other in order to assess overall progress. We have suggested three fundamental categories that could make up a hybrid indicator and how they could be combined, but we also propose the development of an underlying systems dynamics model to assess interactions and synergies over space and time, including both stocks and flows, causes and effects. It is also necessary to develop a framework of policy reforms and societal change that make the achievement of the SDGs possible at both the national and global level. In today's interconnected world, the SDGs cannot be achieved unless there is sustainable wellbeing globally. We hope that the SDG process will continue in the direction we have proposed in order to speed the approach to a sustainable and desirable future.

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