CHAPTER

01

the Inclusive Wealth Index

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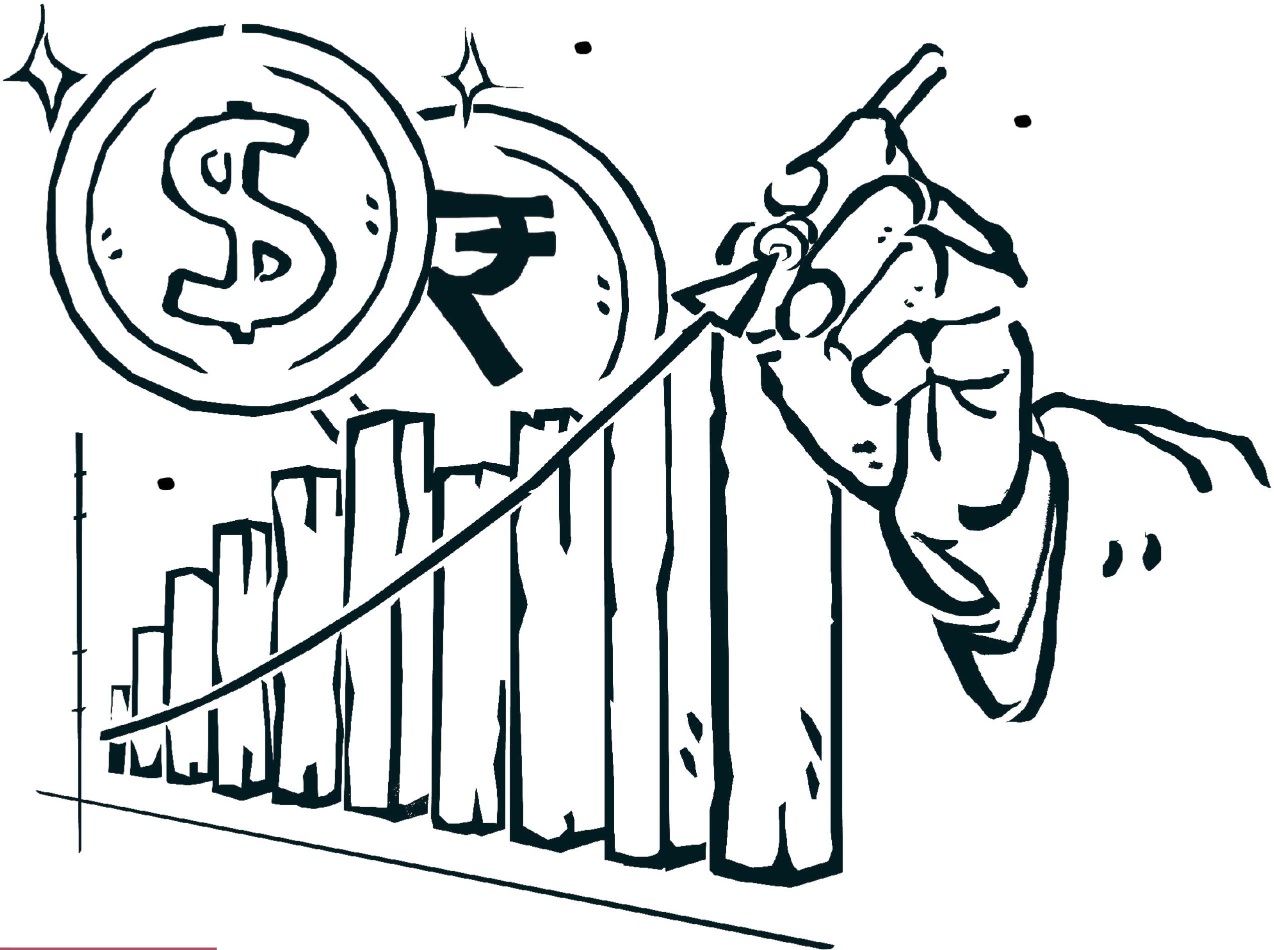
abstract

The Inclusive Wealth Index (IWI) provides a framework for assessing national economic growth and development beyond gross domestic product (GDP). It is unique in measuring the societal value of all capital assets (or stocks) as a set of factors for achieving sustainable intergenerational wealth or well-being. This chapter outlines the theoretical basis for measuring inclusive wealth, as well as specifying an accounting framework. It describes future challenges for, and limitations to, constructing inclusive cross-country accounts of wealth.



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INTRODUCTION

Gross domestic product (GDP) is no longer considered a useful indicator for measuring the well-being of a nation. Simon Kuznets, when developing the means to accurately estimate GDP, warned that it should not be used to measure the welfare of a society; rather it should only be used to measure how effectively a country's available resources are being used. Despite this warning, over the years, GDP has become a mainstay for policy-makers around the world seeking to measure progress and improvement in terms of the overall welfare of society. There are a range of reasons for this. First, the lack of alternative indicators. Second, the simple mathematical elegance of GDP is underpinned by rigorous neoclassical economics. Third, money is used as a standard measure of value. Finally, there has been a strong correlation in the past between GDP growth and the monetary well-being of society.

As economies matured, the correlation between GDP growth and wellbeing began to be questioned •

However, as economies have matured, the correlation between GDP growth and well-being began to be questioned (Stiglitz, Sen and Fitoussi, 2009; Raworth, 2017; Wilkinson and Pickett, 2019; Dasgupta, 2021). Moreover, as climate change began to be recognized as a serious threat to the well-being of societies across the world, the realization that GDP growth is closely correlated with greenhouse gas emissions made it clear that using GDP as the key indicator for measuring progress and societal well-being was no longer feasible or even desirable (Stiglitz, Sen and Fitoussi, 2009).

In addition, in 2015, 193 countries agreed on a set of 17 Sustainable Development Goals (SDGs) that aimed to offer a comprehensive framework within which the key developmental challenges facing global society could be addressed (Gisbert, 2012; Colglazier, 2015). These range from eradicating extreme poverty, to reducing inequalities and greenhouse gas emissions. However, there is no indicator that can be used to assess whether the policies that countries are pursuing in order to meet these goals are protecting and promoting sustainable development (Dasgupta, Managi and Kumar, 2022).

Achieving the SDGs requires more than simply assessing GDP growth (Jean-Paul, 2018; Aitken, Watkins and Kemp, 2019). While GDP measures income stream, it cannot assess the excessive capital loss for increasing income (GDP) in the short run. In the long run, capital loss reduces productive capacity, causing irreversible damage to productive potential. While GDP growth is associated with improvements in many SDG targets and indicators, it may also come at the expense of progress on others. Furthermore, some SDG targets and indicators correlate poorly with GDP growth in either direction. Therefore, SDGs should be linked to a wealth management strategy that considers and uses society's natural, human, social and manufactured assets, and exploits their interdependence. These

IWI measures the societal value of all capital assets as a set of factors for achieving sustainable intergenerational wealth or well-being •

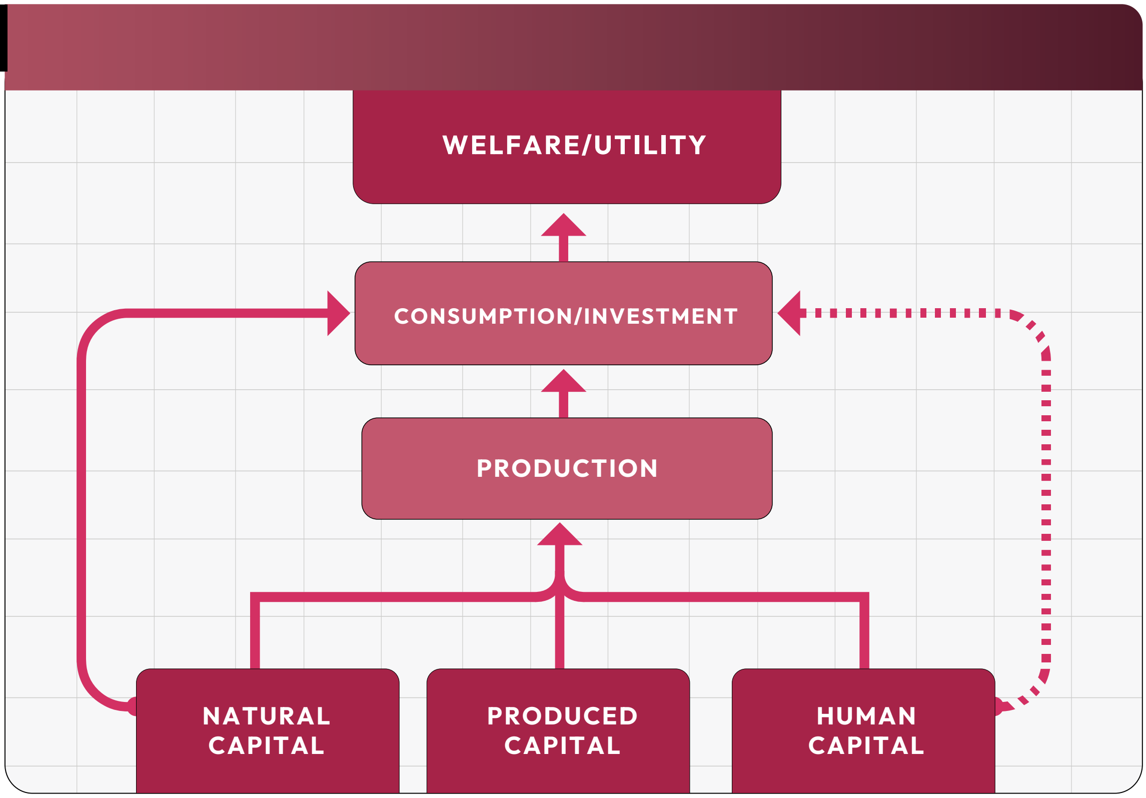
capital assets determine the level of prosperity that can be sustained in the future, known as the inclusive wealth of the economy.

There have been many attempts to provide alternative indicators to GDP to measure and track well-being. Each has its own strengths and weaknesses. In this report, we put forward the Inclusive Wealth Index (IWI) as a measure that takes a very different approach from most existing indicators attempting to measure well-being and sustainability. It does not aim to directly measure the constituents of well-being, instead proposing tracking and measuring the key determinants of well-being. The IWI provides a framework for assessing national economic growth and development beyond GDP. It is a composite measure of a society's productive base based on levels and changes over time, and of human well-being. The IWI is unique in measuring the societal value of all capital assets (or stocks) as a set of factors for achieving sustainable intergenerational wealth or well-being.

In principle, the IWI should include a sufficiently broad and preferably exhaustive, but not redundant, basket of capital assets relevant to current and future human well-being. Classical economics focuses on the input trio of (produced) capital, labour and land, while neoclassical economics deals with capital and labour in the production function. Subsequently, resource economics includes capital and non-renewable resources. In mainstream economics, human capital – the capitalized concept of labour – also plays an essential role in decomposing economic growth (Mankiw, Romer and Weil, 1992).

Figure 1 shows how these three capitals lead to the ultimate purpose of the economy (if any): social well-being. The three capitals are the inputs to the production system; thus, they are called the production

Fig 1.



A three-capital model of wealth creation (Source: UNU-IHDP & UNEP, 2015; Managi & Kumar, 2018)

The economic underpinning of the IWI is that it provides an overview of a country's real progress in the decrease or increase in the overall wellbeing of its present generation as well •

base of the economy. Production capital, such as roads, ports, cables, buildings, machines, equipment and other physical infrastructure, is the easiest to imagine. Human capital includes population (size and composition), knowledge and skills acquired through education, and health (improved quality of life, longevity and productivity). Current accounting for natural capital involves non-renewable subsoil resources, forests and agricultural land, but should ideally include ecosystem services (Millennium Ecosystem Assessment, 2008; United Nations et al., 2014).

Achieving the ambitious SDGs will require mobilizing all societal assets. The IWI can play a key role in supporting this by enabling countries to understand their ability to achieve the SDGs. In addition to the SDGs, the IWI provides support to meet targets for the 2030 Agenda for Sustainable Development, the Paris Climate Agreement and the Beyond GDP movement.

In the next part of this chapter, we discuss the theoretical framework of welfare economics, the basic theory of inclusive wealth and the specifics of empirical cross-national capital accounting, capital composition and consideration of adjustment items.

Welfare maximization requires forecasting consumption, demographic changes, and using natural resources •

2. THE BASIC MODEL

The conceptual framework used for the Inclusive Wealth Report (IWR) begins with human welfare. Welfare depends to a large extent on evolving cultural norms and policies. In turn, welfare affects how society uses different forms of its productive base, which is in the form of capital assets. At the same time, goods and services produced using different capital assets feed back into norms and policies before affecting welfare. Therefore, how different capital assets are used depends mainly on the composition of capital and their respective accounting, also called shadow prices. It is critical to measure non-market natural capital, such as ecosystem services, the decline of which subsequently affects how ecosystems are used, primarily influenced by evolving cultural norms and policies.

In this section, we consider intergenerational welfare at any initial point s ≥ 0. Let C(s) denote the consumption flow vector at time t and U(C(s)) denote economy-wide utility flow. Then use V(t) to represent the current and future social welfare at s, which can be expressed as

(1)

$$V(t) = \int_{t=s}^{\infty} \left[U\left(\underline{C}(s) \right) e^{\delta(s-t)} \right] ds, \delta > 0$$

Equation (1) denotes that maximizing intergenerational welfare V(s) requires forecasting future utility flows and δ indicates the discount rate of the utility flow. In other words, welfare maximization requires forecasting consumption, demographic changes and using natural resources. Nevertheless, forecasting directly by using this information is difficult due to market imperfections such as price distortions and externalities. Thus, considering the counterfactual resource reallocation mechanism, by mapping from the set of all possible capitals into the set of possible pairs of the utility flow for all t›s, it is possible to forecast intergenerational welfare based on whether the initial capital goods stock inherited at s are different from the current time point. Denote $\underline{K}(t)$ as the initial capital goods stock, assume the resource reallocation mechanism is time autonomous, then V(t) is the function of t and $\underline{K}(t)$.

We have:

(2) $$V(t) = V(\underline{K}(t))$$

Combining Equations (1) and (2) yields

(3) $$V\left((\underline{K}(t)\right) = \int_{t=s}^{\infty} [U\left(\underline{C}(s)\right) e^{\delta(s-t)}]ds,\ \ \delta > 0$$

Here we discuss the composition of the capital portfolio K(t). There are many ways to classify capital assets. However, the empirical work needs the capital composition to be measurable. In this research, we carefully divide the capital portfolio into three divisions: produced capital (such as buildings, roads, ports, machinery and equipment), human capital (e.g., population, health, education, knowledge skills) and natural capital (e.g., raw materials, ecosystem diversity). These three capitals constitute the production basis of the dynamic system (see Figure 1). Furthermore, social capital (e.g., institutions and practices) confers use-value on the above three capital goods. By denoting produced capital as M, human capital as H, and natural capital as N, we have K={M,H,N}.

Next, we discuss sustainable development according to the principle of the resource allocation mechanism. Ideal resource allocation means maximizing welfare. We write the perturbation at time t as ΔVt and assume that ΔVt is differentiable. Sustainability is expressed as non-declining welfare through intertemporal changes, so sustainability is maintained if

(4)

$$\Delta V(t) = \Delta V(K(t)) = V\big(K(t) + \Delta K(t)\big) - V\big(K(t)\big) > 0$$

According to the combination of intimal capital goods stock K, Equation (4) also can be written as:

(5)

$$\Delta V(K(t)) = \frac{\partial V}{\partial t} + \left[\frac{\partial V\big(K(t)\big)}{\partial M}\right]\Delta M(t) + \left[\frac{\partial V\big(K(t)\big)}{\partial H}\right]\Delta H(t) + \left[\frac{\partial V\big(K(t)\big)}{\partial N}\right]\Delta N(t)$$

Define

(6.a)

$$p_M(t) = \left[\frac{\partial V\big(K(t)\big)}{\partial M}\right]$$

(6.b)

$$p_H(t) = \left[\frac{\partial V\big(K(t)\big)}{\partial H}\right]$$

(6.c)

$$p_N(t) = \left[\frac{\partial V\big(K(t)\big)}{\partial N}\right]$$

Where $p_i(t)$ is the social value or the shadow price of capital $M(t)$, $H(t)$, and $N(t)$ at time t, let $r(t) = \frac{\partial V}{\partial t}$ be the shadow price of time at t. We can now use shadow prices as weights to construct an aggregate index of the economy's stock of capital assets. We use W,M,H,N, and t to indicate inclusive wealth. The following equivalence between inclusive wealth and well-being is expressed as:

$$W(M, H, N, t) = r(t) + p_M(t)M(t) + p_H(t)H(t) + p_N(t)N(t) \quad (7)$$

and the change in each capital is called inclusive investment, presented as

$$Inclusive\ Investment = p_M(t)\Delta M(t) + p_H(t)\Delta H(t) + p_N(t)\Delta N(t) \quad (8)$$

The IWI provides a capital measure for sustainable development. It links the discounted present value of all future consumption possibilities to the weighted sum of the capital asset (or wealth) profile, which is the productive base of the economic outcome. In other words, invoking the equivalence theorem, Equations (4) and (8) suggest that intergenerational well-being is sustainable as long as the growth of the total capital asset base is positive. Capital assets under the inclusive wealth accounting framework are both intertemporal means of production and direct sources of human well-being that meet the consumption needs of the current population.

The linear functional form of the IWI gives the impression that the wealth/welfare equivalence theorem[1] assumes perfect substitution

1. Wealth/well-being equivalence theorem: a perturbation to an economy that increases social well-being raises inclusive wealth. Similarly, a perturbation that decreases social well-being lowers inclusive wealth (Dasgupta, 2019).

Shadow prices are functions determined by the capital stock, reflecting the extent of substitution among various capital goods in production •

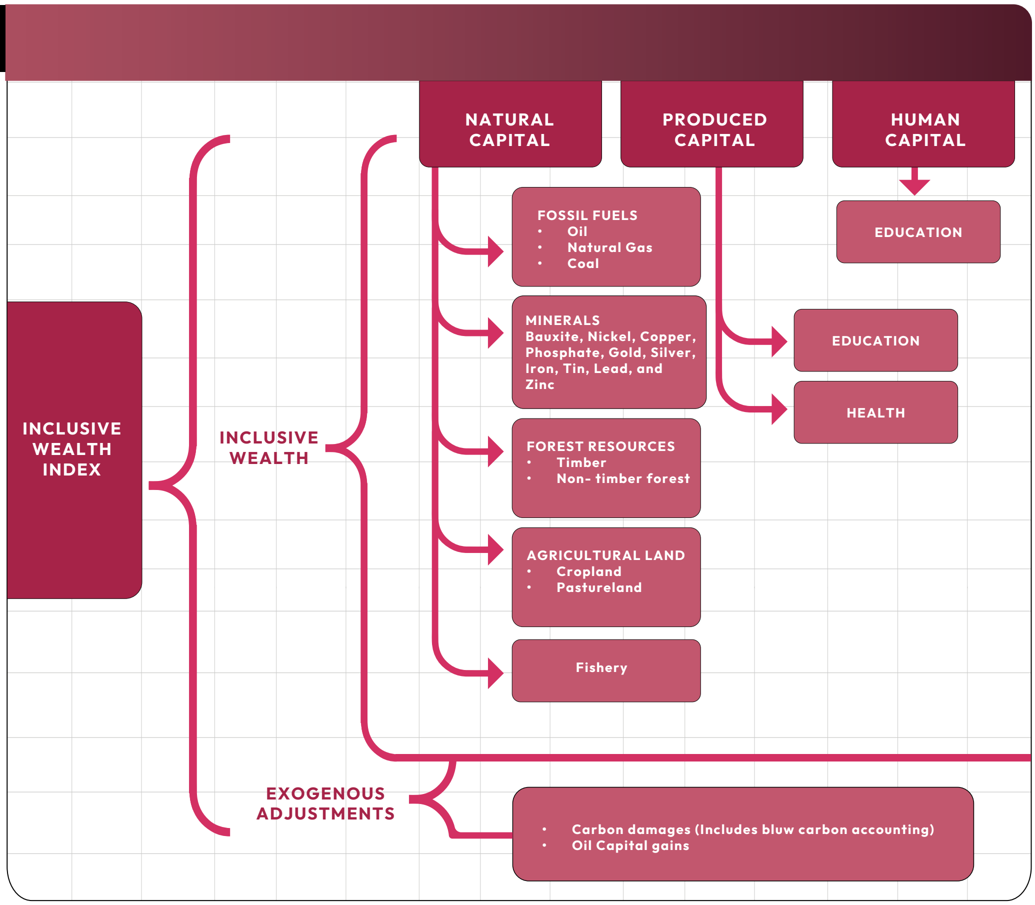
among various capital stocks (Daly, 2007). However, it is worth noting that the derivation of the wealth/welfare equivalence theorem does not explicitly state that one capital good can be completely substituted for by another. The accounting price or shadow prices are themselves functions determined by the capital stock, reflecting the extent of substitution among various capital goods in production. There may be some level of substitution between the primary forms of the three capital bases but it is not absolute.

3. SCHEME OF IW ACCOUNTING

Having outlined the theoretical basis for inclusive wealth, we need to consider how to construct the specific content and framework of the national empirical accounting for the IWI. First, an economy needs to measure levels and changes in various capital stocks at the national level and apply shadow prices to each capital. Furthermore, these levels and changes can be aggregated into a unified index to obtain estimates of inclusive wealth and investment aggregates. Figure 2 illustrates the three pillars of capital assets and adjustments included in the cross-country IWI framework. The framework is similar to that adopted in previous IWRs (UNU-IHDP, 2012, 2014; Managi and Kumar, 2018).

Natural capital accounting is carried out by classifying renewable and non-renewable resources. The current renewable natural resources include agricultural land (arable land and pasture), forests (timber and non-market ecosystem values) and marine fish stocks. Non-renewable natural capital includes energy and mineral resources. Of these, energy sources consist of oil, natural gas and coal, and minerals consist of aluminum, nickel, copper, phosphorus, gold, silver, iron, tin, lead and zinc.

Fig 2.



Schematic representation of the Inclusive Wealth Index and the Adjusted Inclusive Wealth Index (Source: Managi & Kumar, 2018)

An economy needs to measure levels and changes in various capital stocks at the national level and apply shadow prices to each capital •

We calculate human capital using the lifetime income-based method and provide gender-disaggregated human capital statistics. In addition to knowledge and skills, to assess human capital we also need to consider country-specific health and population dynamics. The lags between education investment and returns in developing countries are also transportation equipment, communication equipment and other assets) in capital estimation based on the perpetual inventory method (PIM).

As given in the framework, external adjustments over time need to be considered in addition to the base resource set. We state the consideration of exogenous changes over time in the next section.

We consider three time-varying exogenous adjustments of population change, cross-country externality, and total factor productivity •

4. TIME-VARYING EXOGENOUS ADJUSTMENTS

In the Inclusive Wealth of Nations framework, as shown in Equation 7, time is also considered an asset. However, unlike other capitals, time moves at a constant speed, a speed that it sets itself. Here we consider three time-varying exogenous adjustments of $r(t) = \frac{\partial V}{\partial t}$:population change, cross-country externality and total factor productivity (TFP).

4.1 POPULATION CHANGES

Population growth is exogenous to wealth change. The assumption in Equation (3) considers a constant population, which is unrealistic given rapid population growth in the past and considerable uncertainty around future population projections (Barbier and Hochard, 2019; World Health Organization, 2019). Based on dynamic average utilitarianism, intergenerational welfare $V(t)$ can be expressed as

$$V(t) = \frac{\int_{t=s}^{\infty} P(s)[U(c(s))e^{\delta(s-t)}]ds}{\int_{t=s}^{\infty} P(s)e^{\delta(s-t)}]ds} \tag{9}$$

$P(s)$ represents the population at time s, and $c(s)$ represents per capita consumption at time s. The denominator is a discounted sum of the population from the present to the future. By denoting the vector of per capita capital stocks as $\underline{k}(t)$, rewriting formula (9) to express total welfare as a function of population and per capita capital:

$$V(t) = V(k(t), P(t)) \tag{10}$$

Economic development commonly ignores the exogenous natural capital, thus leading to the unawareness of the adverse health effects of environmental damage •

It can be proved that $\frac{\partial V}{\partial t}=0$ if the welfare changes in Equation (10) are represented only by the capital stock per capita. Thus, development is sustained only if inclusive wealth per capita, valued as constant shadow prices, does not decrease at t (Dasgupta, 2001; Arrow et al., 2012).

Assuming population as the capital input in production, then output increases with population growth. However, in terms of output, increased population affects per capita consumption and welfare. Meanwhile, economic development commonly ignores exogenous natural capital, which means it is difficult to ascertain the adverse health effects of environmental damage (e.g., air pollution, climate change) and the impact of natural capital depletion on wealth. Moreover, in the absence of effective management of private rights and conservation of natural resources, free access to open natural resources is limitless, thereby exacerbating the negative impact of population growth on total wealth, ultimately leading to the tragedy of the commons.

Further, Dasgupta, Mitra and Sorger (2019) demonstrate that, all being equal, the tragedy of the commons occurs if, and only if, total population is sufficiently large relative to natural capital. In developing countries, where little is known about natural capital management and there is high population growth, accumulating human and produced capital to compensate for the depletion of natural capital is difficult, which may lead to inclusive wealth loss, thus exacerbating regional growth inequality (Dasgupta, 2010; Sugiawan and Managi, 2019; Kurniawan, Sugiawan and Managi, 2021). The high depletion rate of natural capital and damage resulting from the interrelationship between population and the environment may affect long-term progress toward achieving local and global SDGs.

4.2 TRANSNATIONAL EXTERNALITY

We also discuss the global environmental externalities of climate change. The environmental impact of climate change comes from CO_2 emissions. While this effect is independent of the wealth accumulation process, the impact of emissions is global and societal. Let $G(t)$ be the stock of global public goods at t, where $G(t)$ is the concentration of CO_2 in the atmosphere. Let $k_n(t)$ be the stock of private assets owned by residents of country n. Then intergenerational welfare can be expressed as the Equation of $k_n(t)$, $G(t)$, and time t:

(11)
$$V_n(t) = V_n(k_n(t), G(t), t)$$

Similar to before, we can get

(12)
$$\frac{dV_n(t)}{dt} = r_n(t) + \frac{q_n(t)dK_n(t)}{dt} + g_n(t)\sum E_n$$

Where $g_n(t) = \frac{\partial V_n(t)}{\partial G(t)}$ is the shadow price of the emission product G, and $\frac{dG_{n(t)}}{dt} = \sum E_n$ is the aggregated emission rate of each country. Equation (12) shows that a country's capital and emissions depend on shared principles and cooperation with the rest of the countries, affecting $r_n(t)$, $q_n(t)$ and $g_n(t)$. Equation (12) hints at the impact of global public externalities on the wealth of countries, which is influenced by the relationship of cooperation between countries and affects sustainable development. For the world, different frameworks have a common future but differentiated responsibilities. On a global scale, reducing the externalities of demographic change and environmental concerns must rely on transnational engagement.

4.3 TOTAL FACTOR PRODUCTIVITY

Technological progress is a time-varying exogenous positive factor that also varies by country. Sustainability can be enabled by increasing productivity, even with declining wealth or an increasing population. Here we denote TFP as $A(t)$, output as $Y(t)$, and capital input as $F(K(t))$, assuming that $F(K(t))$ is constant return to the scale under the steady state:

(13) $$C(t) = Y(t) = A(t)F(K(t))$$

Here, we express the intergenerational welfare $V(t)$ as a function of $C(t)$ and t, the differential of $V(t)$ is

(14) $$\Delta V(A(t), K(t)) = \left(\frac{dV(A(t),K(t))}{dA(t)}\right)\left(\frac{dA(t)}{dt}\right) + \sum_i \frac{\partial V(K_i(t),A(t))}{\partial K_i(t)} \Delta K_i(t)$$

Let $q_{A(t)} = \frac{dV(A(t),K(t))}{dA(t)}$ represent the shadow price of TFP, and the annual TFP change rate is denoted as $\gamma = dA(t)/dt/A(t)$. The shadow price of welfare at t with consideration of TFP is

(15) $$\frac{\partial V}{\partial t} = A(t)/\left[\sum_i p_i K_i(t)\right]$$

In practice, TFP is calculated as a residue of the production function and here considers natural capital as a primary input to eliminate the impact of natural capital input on TFP. In contrast, natural capital is commonly not considered in general economic accounting.

Human capital is the knowledge, skills, competencies, and attributes embodied by an individual that contributes to creating personal, social, and economic well-being •

5. THE COMPONENTS OF INCLUSIVE WEALTH

The theoretical model of an IWI and the cross-country accounting framework are explained above. This section summarizes the empirical accounting for various capital goods and determining their shadow prices, which is complex, requiring time and effort. Below we discuss the capital components and empirical accounting issues in the inclusive wealth cross-country accounting framework.

5.1 HUMAN CAPITAL

Human capital is the knowledge, skills, competencies and attributes (e.g., health) embodied in an individual who contributes to creating personal, social and economic well-being (Schultz, 1961; Becker, 2007). These features are usually slow-moving and remain stable once acquired. Neoclassical economics admits human capital as an essential production element in economic growth; it is also a key determinant of sustainable and inclusive growth. Human capital is expressed primarily through health and education channels, which correspond to SDG 3 (good health and well-being) and SDG 4 (quality education).

We measure human capital by employing an output/income-based approach, also known as a lifelong income-based approach advocated by Jorgenson and Fraumeni (1989, 1992). This measure adds the discounted value of all individuals' expected lifetime income streams. A lifetime income stream is the labour market return an individual expects from an investment in education. The human capital stock (H) is calculated using the following formula:

$$H = e^{\delta * Edu} P_{5+edu} \tag{16}$$

The revenue-based approach relies on the basic assumption that labour wages are paid based on the marginal productivity of his/her human capital •

Where δ is the rate of return to education, Edu is the educational attainment, and P_{5+edu} is the total educated population in the economy. The revenue-based approach focuses on the expected return on investment; therefore, this is a forward-looking measure. This approach relies on the basic assumption that labour wages are paid based on the marginal productivity of a person's human capital.

In this special issue report focusing on human capital and the role of social emotional learning, we apply a lifetime income approach to combine health and education factors, using cohort demographic information from the United Nations Population Division. Our calculations of human capital are based on life expectancy by stages. First, we utilize the EYS by gender to define education attainment. We consider the stage before completing average schooling as childhood because all investment in education occurs in childhood. Second, training and work experience are assumed as age-specific properties. Third, an average education is considered to be completed by an

The shadow price of educational capital equals the sum of the compensated present value of the average expected number of years of service •

adult population and, consequently, the total human capital stock. For adults, we estimate expected years of work (EYW) and years out of the job market based on employment and mortality rates. Finally, the shadow price of human capital is measured in terms of the average unit price of the regular human capital cycle and EYW.

The updated inclusive human capital accounts combine coherent age information about education, population dynamics, health and labour. They measure the economic return on human capital, considering the impact of health, education, gender and economic and social factors. They provide a measure related to sustainability.

The shadow price of human capital is measured in terms of EYW. The logic of this calculation is that, for individuals engaged in employment activities, the remaining years of receiving compensation for education depend on the labour market and the state of health. For the population, the shadow price of educational capital equals the sum of the compensated present value (rental rate) of the average expected number of years of service. We assume the rental rate is constant as an average over the observation period

In addition, parameters for education, health and labour markets information are applied in the cohort modelling. These parameters are critical for the next step in policy analysis. By selecting dynamic population projections and various influencing factors, long-term and short-term human capital changes, such as health losses due to air pollution or educational degradation due to school dropout, can be discussed within this framework.

5.2 PRODUCED CAPITAL

Produced capital is the most familiar and understandable component

Produced capital refers to infrastructure: premises, machinery and equipment, and information and communication technology •

within the wealth framework. It refers to infrastructure: premises, machinery and equipment, and information and communication technology. It includes energy infrastructure, from coal-fired power plants to solar farms, water treatment facilities and distribution networks, and transportation systems, including public transport, roads, ports and airports. It includes factories, machines, computers and office buildings for businesses. For communities, it includes hospitals, social housing and public buildings. Since accounting standards already exist for assessing and measuring changes in the produced capital stock, it is the capital most easily included in wealth accounts at the national or firm level.

Produced capital remains the cornerstone of development and is central to achieving the SDGs. Well-designed infrastructure investments can support goals related to climate change, energy, water, transport, and information and communications technology. However, there may also be significant trade-offs, especially where poorly designed investments lock in carbon-intensive infrastructure for decades. Infrastructure impacts all 17 SDGs and is directly or indirectly related to 72% of them (Thacker et al., 2019). The most significant immediate impacts are SDG 6 (clean water and sanitation) and SDG 7 (affordable and clean energy).

Many strategies exist for measuring and valuing produced capital assets. Direct surveys, insurance data and analysis of company accounts can all yield important information on the stock and value of capital assets. However, these data are only readily available in some countries. Moreover, where they are available, they can be of variable quality and are expensive and time-consuming to compile. Therefore, most studies on produced capital use PIM, which requires only data on the net investment in produced capital (including expenditures and depreciation patterns) and the useful life of assets (Lange, Wodon

PIM estimates total share capital by accumulating past purchased assets over their estimated useful lives •

and Carey, 2018). PIM calculates a balance sheet based on related investment flows. It estimates total share capital by accumulating past purchased assets over their estimated useful lives. The primary input data sources for PIM are capital investment, data about the asset's useful life and the depreciation function that describes the asset.

Considering the net produced capital owned by the country at time t denoted as K_t, and K_t,can be regarded as the net production capital of the previous period plus the capital investment It of the current period and minus the consumption of capital D_t in the current period, then the expression is as follows:
PIM is a model that calculates a balance sheet based on related investment flows. It estimates total share capital by accumulating past purchased assets over their estimated useful lives. The primary input data sources for PIM are capital investment, data about the asset's useful life, and the depreciation function that describes the asset. Consider the net produced capital owned by the country at the time to be denoted as I_t and t can be regarded as the net production capital of the previous period plus the capital investment of the current period and minus the consumption of capital in the current period, then the expression is as follows:

(17)

$$K_t = K_{t-1} + I_{t-1} - D_{t-1}$$

However, accurate capital stock calculations require a complete time series of past investments. Such extensive data requirements may be unattainable for many countries. Furthermore, considering depreciation over time, the proportion of old capital in the current net capital stock will lose value and be zero. Therefore, we assume that old funds still impact current funds within a certain period and use the

We consider four types of capital produced: structures (residential and non-residential), transport equipment, communication equipment, and others •

earliest time as the initial investment time. Calculating the productive capital stock at this point reduces to solving (i) the initial capital stock information at the beginning of the time series, (ii) the investment data time series and (iii) the capital depreciation rate equation.

Previous studies have accumulated much literature on calculating production capital based on PIM. To calculate the initial capital K, we use the steady-state method of Herberger (1978). The practice of this approach can be found in King and Levine (1994) and, more recently, Penn World Tables (Feenstra et al., 2015). We calculate the initial capital stock:

$$K_{t-1} = \frac{I_t}{(\delta+\gamma)} \quad (18)$$

Where δ is the capital depreciation rate, γ is the GDP growth rate that is equal to the investment growth rate and

$$\frac{K_t - K_{t-1}}{K_t} = \frac{I_t}{K_{t-1}} - \delta \quad (19)$$

We use variable capital depreciation rates by country and year to calculate produced capital. These time- and country-varying depreciation rates are obtained by considering a specific capital investment structure. Here we consider four types of capital produced: structures (residential and non-residential); transport equipment; communication equipment; and others. The investment ratios for different capitals are derived from the Pennsylvania World Table (PWT) developed by UC Davis (Feenstra, Inklaar and Timmer, 2015). The table

Natural capital refers to the stock of environmental assets that benefit people through welfare-enhancing environmental goods and services •

measures and compares real and constant GDP across countries. The capital asset depreciation rate refers to the US Bureau of Economic Analysis (BEA) (Fraumeni, 1997). It is worth noting that we use the same set of GDP data to calculate both produced and human capital, and the GDP and investment data refer to the national statistics data of the United Nations Statistics Division (2019).

The latest dataset provides a time series of produced capital stocks in 2015 US dollars for 206 countries and territories from 1990 to 2020. Initial capital estimates were made from 1970 to minimize errors during the study period (for a few countries, we estimate the initial capital stock from the 1990s).

5.3 NATURAL CAPITAL

Natural capital refers to the stock of environmental assets that benefit people through welfare-enhancing environmental goods and services. Stocks include fish, timber, mineral and fossil fuel deposits, and stable climates in oceans and rivers. Ecosystems should also be included in natural capital assets, which contain and combine multiple forms of capital (water, timber, biodiversity and culture).

Natural capital provides an organized intellectual framework for viewing nature through an economist's lens and offers an opportunity to bring the tools of economics to bear on the challenges of conservation and the achievement of multiple sustainable development goals. Incorporating biodiversity and ecosystem values as wealth into natural capital accounting provides a fundamental understanding of the role of nature in human societies: humans are embodied in the biosphere and supported by ecosystems. The importance of ecosystems prompts the assessment and management of this natural capital to be integrated into governments' economic

The shadow price of the capital is assumed to be its rental value, since we assume that the value of a resource is complete externally and depends on resource usage •

investment policy frameworks (Barbier and Hochard, 2018; Dasgupta, 2021; Dasgupta, 2022).

The primary motivation for thinking about natural capital rather than the 'environment' is to apply our understanding of capital theory, capital valuation, net investment management and utilization of capital services to create human well-being (Binner, Smith and Agarwala, 2017). Natural capital accounting for inclusive wealth includes non-renewable resources (fossil fuels and minerals) and renewable resources (agricultural land, forests and fisheries) as natural capital. For non-renewable resources, the stock change is simply the negative of the amount consumed (extracted) during the period, based on the latest stock estimates. The shadow price of the capital is assumed to be its rental value based on the assumption that the value of a resource is complete externally and depends on resource usage.

For renewable resources, we calculate their market and non-market values. Consistent with previous IWRs (UNU-IHDP, 2014; Managi and Kumar, 2018), the ecosystem service values of forests were updated from the Ecosystem Service Assessment database (Van der Ploeg, de Groot and Wang, 2010), and we estimate fishery capital stocks as part of renewable natural capital. Furthermore, estimating fishery stocks simplifies matters by assuming that the fish stocks belong to the country where fishing and stocking occurs. Additionally, in this latest update, we also consider the value of coastal marine ecosystems, which we calculate as carbon storage values and consider an essential component of national wealth.

5.4 ADJUSTMENT

For population change, we measure wealth per capita change to

Carbon damage, oil capital gain, and total factor productivity are three time varying factors that are considered as "adjustments" in the IWI methodology •

exclude the impact of time variants. In addition, there are three time-varying factors affecting wealth and social well-being that are not covered by familiar capital assets. These are carbon damage, oil capital gain and total factor productivity. These are calculated and considered 'adjustments' in the IWI methodology. For these adjustments, we first calculate the impact of greenhouse gas emissions as the global externality of climate change. The cost of global greenhouse gas emissions is estimated in the unit of CO_2 damage. Accounting for greenhouse gasses includes two types: (1) carbon emissions from fossil energy sources; and (2) increased emissions from deforestation. We then follow Nordhaus's method to allocate carbon emissions to countries based on the country's or region's GDP proportion of global GDP (Nordhaus, 2011). In particular, we introduce the effect of blue carbon (i.e., carbon stored in coastal and marine ecosystems) on carbon damage. However, since there is only a year of blue carbon accounting data, this aspect is not reflected in the analysis of the results.

We follow the non-parametric approach introduced by Olley and Pakes (1992) and Levinsohn and Petrin (2003) by using proxy variables to construct a trans log production function in which natural capital is treated as a free variable for production inputs, as is human capital. This estimate separates the contribution of natural capital from production from technological innovation, the role of creativity in production, and other implicit capital that has not yet been considered in building a nation's inclusive wealth.

Finally, we consider the capital gains of oil exporters on depletable resource inventories and the corresponding losses of oil importers. In a closed economy, price increases for an exhaustible resource are negligible because prices balance gains and losses for producers and consumers. However, in a group of interconnected open economies, exporters can expect higher prices (and thus have greater control over

We describe specific future challenges for constructing inclusive cross-country accounts of wealth, including practical considerations and limitations •

future goods), and importers suffer accordingly. Conversely, importing countries may have fewer investment opportunities due to higher oil prices, so oil capital losses are distributed to consuming countries.

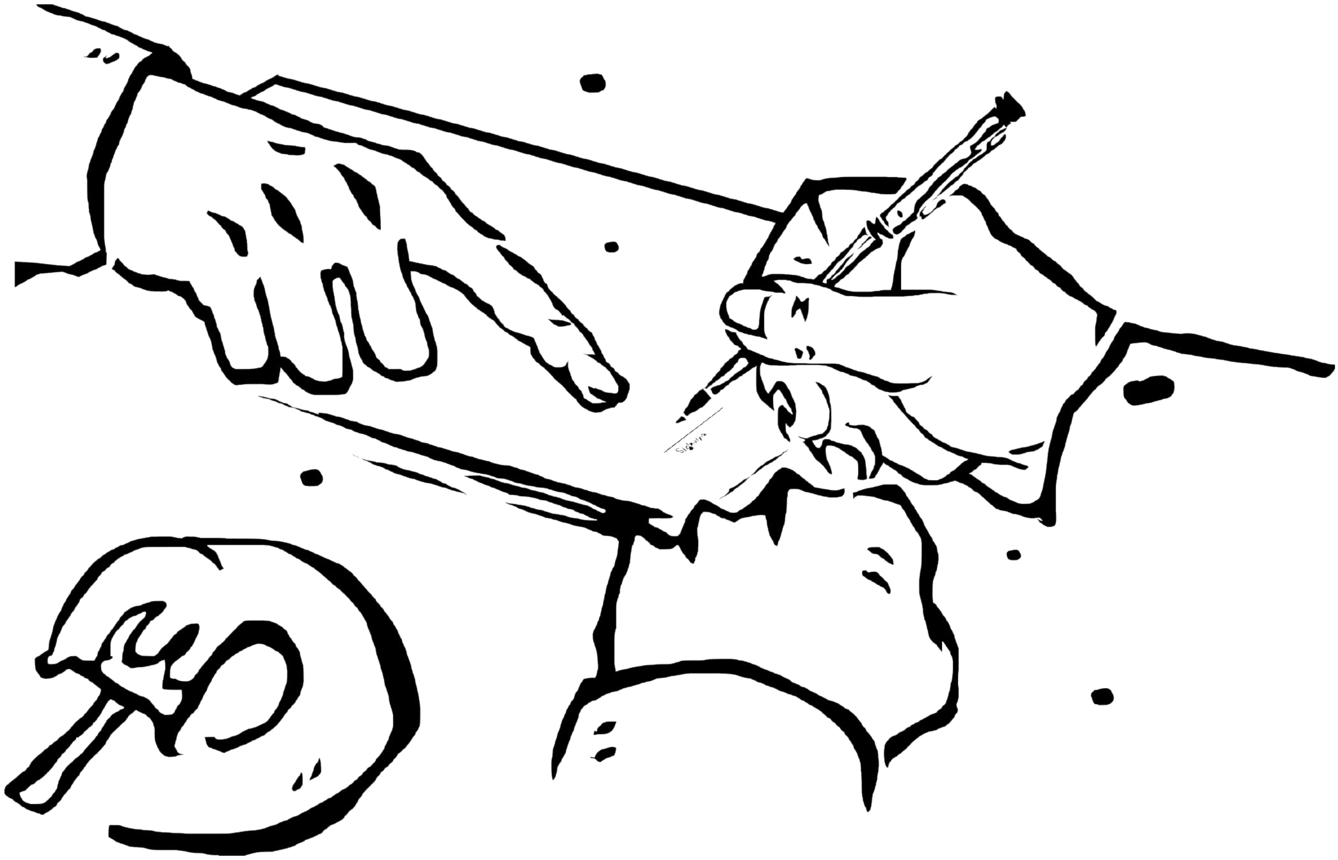
6. CHALLENGES

In this section, we describe specific future challenges for constructing inclusive cross-country accounts of wealth, including practical considerations and limitations that should be considered along with the findings.

The lack of current data forces us to leave out values of some key natural capital ecosystem services. Moreover, while reporting on the mining (or production) process of minerals is ubiquitous, estimates of mineral reserves need to be further completed. Global water accounts also need further refinement and we need to begin including the value of marine ecosystems.

Another area of concern for future reports is the dichotomy between production- and consumption-based accounts. Production-based accounts record the depletion of resources within a country's borders within a year, regardless of where those resources are ultimately consumed. Consumption-based accounts capture the depletion of resources reflected in a country's demand for consumption goods and services, regardless of where these depletions occur (Lenzen et al., 2013). Examining both sets of accounts together provides a complete picture of an economy's contribution to national and global sustainability (United Nations et al., 2014). Insight into dependencies on domestic versus global resource stocks is critical to understanding resource security issues.

Among other things, our estimates of human capital lack information



Expanding the scope of inclusive wealth accounts requires us to refine the data further and evaluate inclusive wealth from a more comprehensive perspective •

on differences in human capital compensation between male and female populations. Therefore, the shadow price of human capital cannot fully reflect the differences in social values of different gender groups.

In the case of produced capital, we use the latest PWT database (from 2020) capital structure for production capital estimates. However, due to the intertemporal baskets of consumer goods and services, they may have different prices. Therefore, purchasing power parity or inflation index adjustments have been implemented across countries, which improves comparability across countries but mitigates the real potential difference from the purchase side.

Other valuation issues may also arise when using wealth measures at the level of an intertemporal framework. For example, in terms of natural capital, the interpretation of the values used in the non-timber forest accounts relies on the estimated benefits per unit of forest based on global averages. This approach may not fully capture the rising value of these resources due to depletion. Moreover, forest stocks are valued using period-specific marginal prices, ignoring the changes in willingness to pay overtime, especially in situations where

The IWI can be an appropriate composite indicator to be used in conjunction with the many existing goal specific indicators used to monitor the SDGs to ensure overall sustainability for societies across the world •

there is resource depletion. Additionally, using global averages may not be accurately representative of all countries. These questions might lead to misleading conclusions when comparing wealth or per capita wealth changes over time.

In short, expanding the scope of inclusive wealth accounts requires us to refine the data further and evaluate inclusive wealth from a more comprehensive perspective. Despite these limitations, the trends we observe across a wide range of capital assets and their analysis provide essential insights and knowledge for discussing sustainable development outcomes and trajectories for the future.

7. CONCLUSION

There is no doubt that the wealth of countries is changing, and the composition of that wealth, in terms of capital stocks, is also changing – and not necessarily on a sustainable path for many countries. We recommend that decision-makers are cognizant of the changes in the productive base of their societies and act accordingly to ensure that the welfare of future generations is as high or higher than that of the present generation.

By showing how countries around the world use inclusive wealth accounting in policy formulation and target setting, policy assessment and monitoring, and economic modelling and analysis, this report demonstrates the need for more detailed and broader information to support national capital accounting.

Estimating each capital requires multiple database entries, and integrating all IWI data into a unified country time series is critical for inclusive wealth accounting. In this report, we present IWI country time-series data for 38 countries, acknowledging that they are incomplete. The IWI can therefore be considered an appropriate composite indicator to be used in conjunction with the many existing goal-specific indicators used to monitor the SDGs to ensure overall sustainability for societies around the world.

Finally, we assert that experience has shown that the ability to mobilize assets is critical to addressing shared global challenges. Public investment can provide the foundation to support a sustainable, inclusive, resilient and prosperous recovery worldwide if capital assets can be managed in concert and allocated effectively.

KEY MESSAGES

Gross Domestic Product (GDP) is no longer a useful indicator for measuring the well-being of a nation.

The Inclusive Wealth Index (IWI) provides a framework for assessing national economic growth and development beyond GDP. It is a composite measure of a society's productive base based on levels and changes over time and human well-being.

This chapter discusses each of the capital components of the inclusive wealth cross-country accounting framework individually, as well as associated empirical accounting issues.

This chapter describes specific future challenges and limitations ffor constructing inclusive cross-country accounts of wealth.

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