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Working paper

Years of Good Life (YoGL): A new indicator for assessing sustainable progress

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Abstract

The Sustainable Development Goals (SDGs) consist of 17 goals with 169 targets and 230 indicators. They provide a wide-ranging set of partly overlapping and partly contradictory social, economic and environmental goals which are important in their own rights but are almost impossible to measure in their entirety to assess whether overall there has been progress or not. This paper proposes the opposite approach; it defines one quantitative indicator for overall quality of life which can be applied to any sub-population of humans and over a long-term horizon, allowing for the inclusion of feedback from environmental change, and measuring whether there has been any genuine progress or not. We define this indicator as Years of Good Life (YoGL) which is based on the fact that in order to be able to enjoy any quality of life, first and foremost one has to be alive. While life expectancy is at the basis of this indicator, it also reflects that mere survival is not enough, life years need to be weighted by subjective and objective factors in order for them to measure years of good life. The objective variables considered are being in acceptable health (as measured by activity limitations), being out of poverty (as measured by a basic-needs approach) and being cognitively fit (as measured by tested literacy). These also refer to the dimensions of capable longevity as suggested by Sen. Only life years that both satisfy the minimum levels of these objective criteria, and at the same are time are associated with positive life satisfaction, as a subjective indicator, are counted as ′good years' in the YoGL indicator. Technically, this is done on the basis of demographic life table methods where the person-years lived at each age are multiplied (following the Sullivan method) with the proportions of people at each age that are above the critical quality of life thresholds.

This paper discusses the requirements needed for a new indicator, such as YoGL, to be used as a sustainability criterion and as the dependent variable of a well-being production function. These requirements include (1) the need to be based on observable individual characteristics that can be flexibly aggregated to (sub-) populations, and (2) have substantive meaning in its absolute level that can be compared across populations and over long timespans. The paper also compares this new indicator to other existing indicators in terms of theoretical framework, criteria and calculation methods, and discusses the advantages of YoGL with regards to meeting the specified criteria. It also includes examples for how YoGL can be calculated and estimated empirically based on survey data.

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Introduction

The 17 goals and 169 targets approved on September 25, 2015 by the leaders of 193 countries were the result of an extensive international consultation process, which included hundreds of discussion fora around the world organized by international agencies, national and local governments, as well as civil society. This may have been the broadest ever consultation process in human history. The resulting structure created a list of goals and targets which broadly satisfied the needs of the major participants of the consultation process; the global health community got a goal specifically on health (SDG3), the education community SDG4, the development banks the poverty goal (SDG1) and the food and agriculture community SDG2. But given the large number of stakeholders with specific priorities and policy agendas, the outcome of this bottom up process inevitably resulted in a number of priorities which overlap with, or contradict one another. To assess progress towards these goals a set of 230 indicators has been defined, which requires data to be collected in all countries of the world, since the SDGs apply globally irrespective of a country's current economic standing.

Given this large set of targets, some of which overlap or contradict one another, it has been stated that the SDGs lack a sense of priority and the 'wood is not seen for the trees' (Lutz, 2017a). There is an obvious tension between the agreed political statement that all 17 SDGs are of equal importance and together constitute an "indivisible and integrated" agenda, on the one hand, and their undeniable heterogeneity, on the other hand. In addition to the mentioned overlaps and contradictions, the goals are also of quite different nature, with some of them – such as good health – seen as ends in themselves and others – such as clean water – as a means to other ends. It is also evident that, in practice, not all 169 targets can get equal attention and equal funding. It is therefore necessary to substantively and scientifically address sustainable development as a whole by including all the synergies and interactions, and viewing instrumental goals and end-goals in their proper places. This does require a systemic approach that is universal and place-specific at the same time.

As a step into such a direction, a new and ambitious research project aims to significantly advance the scientific understanding of the priorities needed to ensure sustainable human development over the remainder of this century. This holistic perspective takes account of the many pressing challenges posed by inequality between and within countries, continued world population growth associated with rapid urbanization, new health challenges, and, in particular, global environmental change (Lutz, 2017b). But before entering the daunting task of specifying and estimating a "production function" of sustainable human well-being – which this project ultimately intends to do – it is first necessary to decide what outcome variables should be placed on the left-hand side of such a function. A single index needs to be defined that measures the essential dimensions of human well-being and can be used to estimate such well-being production functions, not just at the national level but also for well-defined sub-populations of interest. In other words, instead of going for 230 indicators whose relationship to each other is unclear and which cannot be meaningfully used for the purpose at hand,

we suggest measuring progress towards the SDGs by one carefully crafted well-being indicator that is fit for purpose and, at the same time, broadly acceptable as an ultimate end, even under different cultural perspectives.

This indicator has been tentatively labelled YoGL (Years of Good Life). The purpose of this paper is to derive it from *ex ante* defined criteria that should be met. The paper will discuss the empirical data necessary to estimate it and the methodological issues involved in calculating YoGL. Finally, this new indicator will be discussed in comparison to a wide range of existing indicators, placing a specific focus on each indicator's suitability to the specified criteria.

A well-being indicator in the context of sustainability science

The emerging scientific field of sustainability science addresses the interactions between natural and social systems in the most comprehensive way possible. Yet, in the words of one of its founders, Robert W. Kates, any comprehensive quantitative operationalization of the concept still suffers from the "ambiguity of sustainable development, the plurality of purpose in characterizing and measuring sustainable development, and the confusion of terminology, data, methods and measurement" (Parris & Kates 2003, p.559). Given this "confused" state of affairs, what can this project do that the rapidly expanding body of literature in sustainability science has not been able to achieve so far? In short, the answer is that here we try to define one ultimate target of sustainable human well-being in the form of a quantitative indicator that can be empirically measured for variable sub-populations and forecast as a function of a set of drivers that can be specified and modelled.

In a review of the state of the art in sustainability science, Bettencourt and Kaur (2011) identified 21.5 million documents on the theme of sustainable development alone. Many of them study very particular aspects of human-environment interactions without asking the core underlying question of how the different factors influencing the relationship between humans and their environment jointly affect human well-being and what the policy priorities for improving the human condition of current and future generations should be. Or in the words of Geoffrey B. West: "No overarching integrated framework has yet been developed that can provide a long-term picture uniting the many highly inter-related themes underlying sustainability. Existing approaches have, to a large degree, failed to come to grips with the essence of the long-term sustainability challenge; namely, *the pervasive interconnectedness and interdependency of energy, resources, environmental, ecological, economic, social and political systems."* (West 2010, p.11).

These interconnections are at the heart of the research questions that matter the most for the future of the human condition on this planet. Without gaining a comprehensive analytical understanding of them, we are not in the position to say what is "dangerous" for future human well-being and what is less so. The 1992 UN Framework Convention on Climate Change asked for avoiding "dangerous" interference with the climate system. But how can we assess what is dangerous? Vaclav Smil in many of his writings (see for example Smil 2005) has addressed this issue and compared different dangers for future well-being, ranging from pandemics to nuclear war to meteorite impact. Groups such as the Copenhagen Consensus have tried to explicitly address this question by asking where a given dollar would be better invested in terms of delivering better outcomes for human well-being. Much progress has been made in the field of global level integrated sustainability modelling, such as the GISMO Model (Hilderink et al. 2008) and the Pardee International Futures Model (Hughes & Hillebrand 2006). Yet, none of these efforts have done so in a comprehensive systems-analytical way that has clearly specified ultimate ends (well-being indicators), a clearly specified well-being "production function", and a clearly structured and documented transparent systems model on the various feed-backs that is applicable for specific settings.

More progress has been made at the level of specific Population-Development-Environment (PDE) case studies. In the early 1990s a pioneering study developed a very detailed model (including population, socioeconomic development, water, land use and many other dimensions) for the island of Mauritius 1960-2030, thus reconstructing the past and estimating scenarios for the future 1960-2030 as a micro cosmos with good statistical information (Lutz 1994). Mauritius had served as a text book example of a country trapped in the vicious circle of poverty, population growth and environmental degradation, yet managed to escape it – a fascinating experience that was also used to assess the validity of the Ehrlich versus Simon arguments about the effects of population growth(Ehrlich & Ehrlich 1990). Similar case studies taking a comprehensive approach and using tools of dynamic systems analysis were then carried out at IIASA for the Yucatan Peninsula, Namibia, Botswana, and Mozambique, all resulting in scientific books, reports and many refereed articles (for a summary see Lutz & Shah 2002). Another series of population-environment case studies was carried out in the context of the MacArthur Foundation-financed Population-Consumption-Environment (PCE) Initiative which commissioned more than 30 case studies in this field and published a special issue of *Ambio* (Curran et al. 2002). One of the problems of all these case studies was that they did not use a unified research framework that allows for consistent comparisons across case studies and in particular that they did not study the complex PDE interactions with respect to common outcome variable that is considered an ultimate end.

When trying to define indicators of human well-being it is useful to follow the distinction between means and ends made by Herman Daly and later elaborated by Donella Meadows who distinguishes between ultimate ends (human well-being) and intermediate ends (human and social capital), as well as intermediate means (built and human capital) and ultimate means (natural capital) (Meadows 1998). Following this approach, in this paper we are looking for indicators of ultimate ends. While the literature abounds with a very wide range of sustainability indicators, they often mix ends and means and are often difficult to interpret. It is also intellectually unsatisfactory to synthesize many different aspects into a single number because of the mostly arbitrary weights given to the different aspects and the fact that an abstract index number has no substantive interpretation in terms of an analogy to something in real life.

The Human Development Index (HDI by UNDP) is the best known example of such an index that gives equal weight to education, health, and income indicators and works on a relative scale, hence cannot be compared over time (UNDP 2011). It also mixes means (such as school enrollment) with ends (such as survival as measured by life expectancy). While very useful for comparing countries at any point in time it has no individual level equivalent and thus cannot be applied flexibly for sub-populations. And because of its relative nature it is problematic for long-term trend analysis. As discussed below in the context of a comparison of many different indicators that have been proposed, it is therefore not appropriate for serving as a long-term sustainable development criterion.

Another possibility of approaching the issue of finding an indicator of ultimate ends whose change over time can be used as a sustainability criterion is the needs based approach which is directly reflected in the definition of sustainable development of the Brundtland Commission (1987). It refers to *development that meets the needs of the present without compromising the ability of future generations to meet their needs*(WCED 1987). But the report of the Commission only uses the notion of “needs” without giving it a clear definition. Gough (2014) defines needs in terms of a hierarchy moving from universal goals through basic needs to intermediate needs. He defines the universality of needs through the belief that if needs are not satisfied then serious harm of some objective kind will result. Serious harm is defined as the significantly impaired pursuit of goals which are deemed to be of value by individuals. Serious harm is “fundamental disablement in the pursuit of one’s vision of the good, whatever that vision is” (Gough 2003). In his view this is very different from subjective

feelings like anxiety or unhappiness. Basic needs are then defined as the preconditions for non-impaired participation in any form of life (Gough 2014). And he defines health/survival and autonomy as the most fundamental basic needs. This comes very close to the approach taken in this paper where the notion of autonomy is operationalized through the set of three dimensions of objectively measureable empowerment that constitutes good years of life. It moves the concept of needs closer in the direction of Sen's capability approach (Gaertner 1993; Sen 1997), who has criticized the needs approach as being too passive. Hence, instead of impairments in the pursuit of a good life we will focus at the enabling factors and the positive outcomes they produce.

Criteria for choosing a fit for purpose well-being indicator

The broader field of well-being indicators is mushrooming. Constantly, new indicators are being proposed, both by different organisations, as well as individual scholars and in the latter part of this paper, we will discuss ten of these indicators in more detail and compare them critically to the new YoGL indicator being proposed here. Much of the development in the field seems to be driven to a large extent by the well-justified desire to go beyond GDP, which until recently has been the hegemonic indicator of progress in policy circles, business communities and the public at large. This desire to go beyond GDP has been highlighted by the prominent study "Mis-Measuring our Lives" where the economists Stiglitz, Sen and Fitoussi (2010) discuss appropriate metrics aside from GDP per capita and ask whether it should be a single metric or a 'dashboard'. In their conclusions they clearly state that sustainability assessments require a well-identified dashboard of indicators. But they also stress that the assessment of sustainability must be examined separately from the question of current well-being. And they warn against mixing or blending indicators of current well-being with indicators of sustainability that mostly will play out in the future.

While many of the more recent proposals for indicators follow the suggestion of producing a dashboard by covering indicators from a broad range of domains they do not follow the suggestion with respect to separating the measurement of current well-being from the issue of sustainability. The Happy Planet Index (Abdallah et al. 2012), for instance, combines current mortality conditions as summarized by life expectancy and data on life satisfaction and the ecological footprint of each country. While mortality and stated life satisfaction are measures of current well-being, the ecological footprint is not directly reflected in current conditions but tries to measure possible impacts on future conditions, thus referring to sustainability. It therefore has a dual function which makes its direct interpretation difficult. The conceptually clearer way – following the suggestion by Stiglitz et al. (2010) – would be to have an indicator that only reflects current conditions at every point in time but then study it over longer time periods (including possibly projections for the future) and see how this period indicator possibly declines as a function of deteriorating environmental conditions.

The OECD Better Life Index is more consistent in this respect of only reflecting current conditions (Lorenz et al. 2017). It offers the user eleven domains ranging from current conditions in housing and income to life satisfaction and work-live balance and allows the user to freely use the weights he/she wants to attach to each domain when producing and aggregate indicator across domains. Even in the domain of environment the indicators are limited to current conditions in air pollution and water quality and do not have any indicators on CO2 emissions, loss of biodiversity or other aspects that would primarily affect future well-being. While the approach is very consistent in this regard, at the same time it is not designed for the analysis of sustainable development. It also shares with other broadly based multi-dimensional indicators, such as the multi-dimensional poverty index, that it depends on a large number of empirical measurements collected by surveys and for this reason can hardly be projected into the future on the basis of a model. Any forecast of an indicator requires a

model because there are not yet any empirical measurements for the future. And in general it is true that the simpler the indicator, e.g. just one number, the better one can define a model for forecasting it under certain constrains and assumptions including possible feed-backs. For this reason, meaningful model-based long-term scenarios exist e.g. for life expectancy and even GDP per person but it would be nearly impossible to come up with a forecasting model of the Better Life Index.

The approach chosen for YoGL goes into the opposite direction by defining an indicator that consists of one number with substantive meaning (instead of just an index) and restricts itself to reflecting only five dimensions that are considered most essential for well-being at any point in time and for any population or sub-population: Survival, subjective life satisfaction and the three objective aspects of capable longevity, namely being out of poverty, being cognitively enabled and having no serious physical disabilities.

Of the many well-being indicators that have been proposed recently, presumably each has been designed with a specific purpose in mind. The quality and usefulness of any proposed indicator has to be assessed with respect to the specific purpose it has been created for. In the rest of this section we will thus explicitly list the set of criteria that we had in mind when designing the YoGL indicator to fit the purpose of becoming a broadly acceptable criterion variable for judging whether developments are sustainable over time or not, where developments are considered as "sustainable" if they do not lead to a decline in YoGL for any population or sub-population of interest in the longer-term future. We will return to the more specific operationalisation of this general definition later in the paper. For now we want to turn to the list of criteria the indicator has to fulfil.

The main prerequisite for any indicator of well-being is that it can stand alone on the left hand side of a well-being production function. As proposed by Clark (2012), it should be a quantitative estimate of the variable W in the formulation of a function relating well-being to a combination of independent factors, in Clark's case human capital, manufactured capital, natural capital as well as institutions and knowledge.

$$W = f(C_i, I, K)$$

W is 'human well-being' (intra and inter-generational)

C_i are 'Capital Assets' (from which services flow)

- C_m is 'manufactured capital' (factories, homes, roads)
- C_h is 'human capital (population, health, education)
- C_n is 'natural capital (ecosystem and their services)

I is 'Institutions' (laws, rules, norms, expectations)

K is 'knowledge' (scientific, practical, innovation)

In the context of this paper we will not attempt to estimate empirical functions of this sort and for this reason also not discuss the theoretical and methodological issues. This function is only mentioned here to illustrate the purpose of our endeavor of defining an operational well-being indicator that should take the role of W on the left of such a function, while all the determinants of well-being, i.e. the means and intermediate ends should be on the right side.

Before going into the more detailed criteria it is also important to be clear about the fact that W here refers to human well-being and not to other possible kinds of well-being such as that of specific

animals or Mother Nature in general. In this sense we have a clear and transparent focus on "population-based" sustainability science which is explicitly anthropocentric in the sense that it is radically focused on long-term human well-being as the ultimate end of sustainable development.

The new well-being indicator YoGL has been defined in a way that it should meet all of the following six criteria:

(1) It needs to be based on **characteristics of people** that can be flexibly aggregated to **sub-populations**.

Since the basis for every such indicator rests entirely on the well-being of people it should be possible to build it bottom-up based on individual characteristics that are observable and measurable (or at least possible to estimate quantitatively) for individual people. Such an approach also makes it possible to calculate the indicator for groups of people other than just national populations. A focus on sub-populations is essential for answering many of the important questions that are asked in sustainability science and also tend to be important for ethical and political considerations: how does the well-being differ by gender; how does it differ among various ethnic or socio-economic groups in a population; how does it differ between residents of urban and rural populations or different administrative districts or other geographic units? The possibility to assess the well-being of sub-populations rules out dimensions of an indicator that only exist at national level, such as conventional macro-economic national accounting. The widely practiced and almost exclusive focus on indicators at the nation state level is problematic under the long-term perspective inherent in the concerns of sustainable development because nations come and go and change their boundaries. Most of today's United Nations member states did not exist in their current form a century ago and it is unclear in which form they will exist by the end of this century.

(2) It needs to have a meaning in its absolute value in order to make the indicators **comparable over time and across sub-populations**.

For being able to compare the well-being of certain populations at two different points in time and see whether there has been an improvement or deterioration the chosen indicator must have a meaning in its absolute value and not just be defined on a relative scale that depends on other time varying indicators. As an example, the life expectancy component of the HDI is defined as a fraction of the maximum national life expectancy observed in any given year. Hence, when comparing this mortality index (given in the form of a fraction) for a given population, say for 1990 and 2015, it is impossible to see whether survival conditions in this population actually improved over time and by how much. In its relative form the mortality index can only show whether the given population improved its relative standing to the country with the highest life expectancy.

(3) It needs to describe something as the ultimate end that has the potential to **be universally shared across all cultures** as a highly desirable state.

The use of any well-being indicator only makes sense as far as there is near consensus that it describes a highly desirable target. The aspiration is to capture the single most important ultimate end that people with very different orientations, values and cultural backgrounds would be ready to subscribe to. It should describe something that a Wall Street broker, a Buddhist monk and a member of a traditional nomadic tribe would all, at least in principle, find most desirable. While the actual acceptance of the indicator as an ultimate end will later in this project be empirically tested in different settings, at this point we can only *ex ante* exclude some candidates for such an indicator for which we can already see groups that would clearly object to it. Another test that can be made at this early stage is to envision several rare and rather extreme voluntarily chosen life styles (such as an

eremite monk) and consider whether the indicator would likely be acceptable as the description of a highly desirable end to such a person as well.

(4) It should be theory based and cover only a hand full of dimensions that are considered absolutely essential and the aggregate indicator should **not be based on arbitrary weighting schemes** such as giving every dimension equal weight or any other not theoretically argued weighting.

There seems to be broad consensus in the literature that any one dimension alone would not be sufficient for adequately measuring human well-being or even the ultimate end of human existence. Any such one-dimensional indicator would likely suffer a similar criticism as GDP per person. Even life expectancy, which has been suggested as a possible candidate for being the single best indicator covering and reflecting many key dimension of well-being, would not serve this purpose because it only reflects the combination of age-specific survival rates in a life table. Many people argue that mere survival is not good enough because what one should be measuring is years of good life rather than only years of life. On the other hand, there should not be too many dimensions and the ones that are being considered should have a clear theoretical grounding. As part of this theoretical foundation of the chosen indicator it is also desirable that the different dimensions are combined in a substantively justified way and not only based on some more or less arbitrary weighting.

(5) It needs to be based on sufficiently large empirical information for different populations and **fit for serving as the dependent variable** in international regression models ("production functions").

Since this indicator shall be estimated for a large number of populations at different points in time its constituents need to be based on statistical information from survey items that have already been frequently used in different sets of international surveys. To be able to be used as the dependent variable in large empirical studies it is also desirable to have the indicator in the form of just one number.

(6) If possible, it should have a substantive interpretation in terms of some **real life analogy** rather than just being an abstract index.

An additional strength of the indicator would be to not only give an abstract index value but rather something that has real life analogy, such as GDP/person is suggestive of the amount of money a person has at his disposal or life expectancy gives a number of years that can be interpreted. It would just be more attractive and intuitive to say that in population x the average person has 66 years of good life while in population y it only has 54, rather than a well-being index being 0.753 and 0.683, numbers that people cannot associate anything with.

The three levels and five dimensions of YoGL

When constructing YoGL to meet the above described criteria a clear hierarchy of dimensions to be covered was established on theoretical grounds. First and foremost, we consider survival as the most essential prerequisite for enjoying any quality of life. But since mere survival is not considered good enough by many people, in a next step we go on to define good years of life as such where people are above a minimum level both in terms of objectively observable conditions and in terms of subjective life satisfaction. At a third level, the objective conditions that should cover capable longevity are further broken down into three dimensions: being out of poverty, being cognitively enabled and having no serious physical disabilities.

Figure 1: Dimensions of Years of Good Life - a human well-being indicator

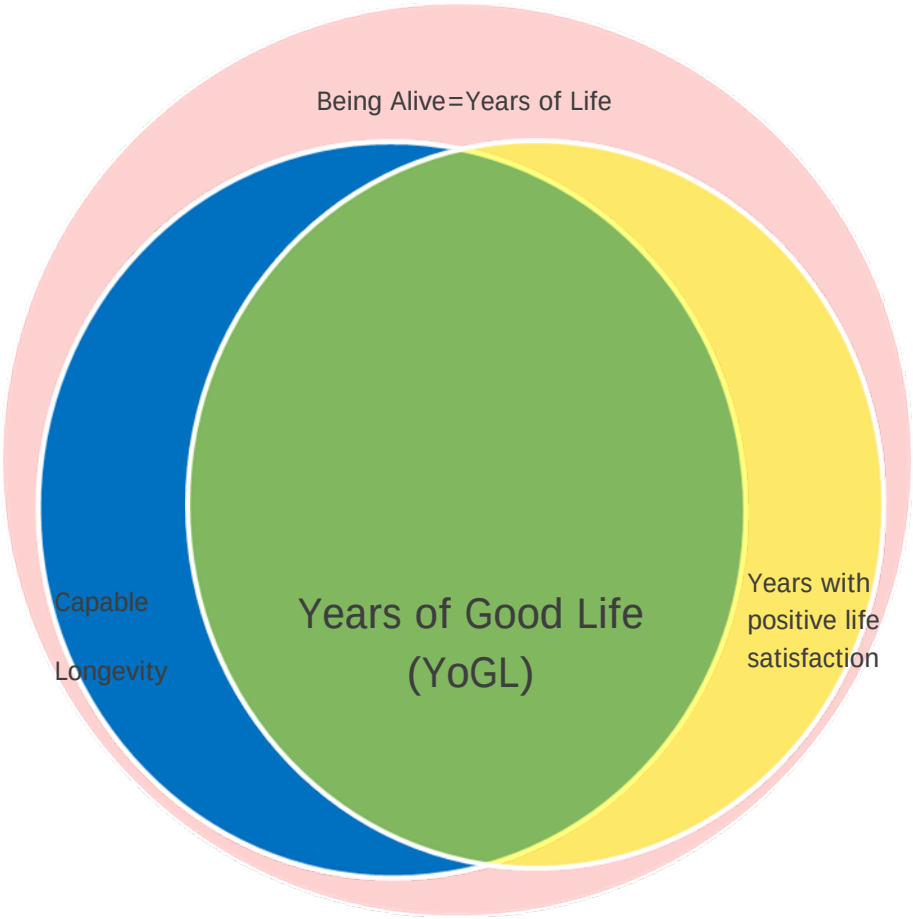


Figure 1 summarizes this structure and basic logic of YoGL. The big red circle shows the overall years of life which – based on a life table – summarize the expected length of life of a person based on the currently observed mortality/survival rates in the chosen population. The Years of Good Life are a subset of these overall years of life that result from the overlapping area (green area) of the capable years of life (blue circle, defined by three objective criteria) and years with subjective life satisfaction above a minimal level (yellow area). In other words, years of life are only counted as good years of life if they are above a minimum threshold both in terms of objective well-being dimensions as well as subjective life satisfaction.

In the following, we briefly summarize the reasoning behind each of these levels and dimensions:

1. **Total life expectancy**

Life expectancy is a widely used demographic indicator that is being calculated on the basis of observed age-specific mortality rates, and combined in a life table where the mortality rates are first converted into age-specific survival probabilities and a multiplicative combination of these probabilities can then be used to derive average durations of remaining life expectancy at different ages. Most frequently, life expectancy at birth is given, but for studies of ageing often life expectancy at age 65 is also used. In the context of YoGL, we will primarily use life expectancy at the age of 20 because many of the indicators used (such as life satisfaction) are not generally assessed for children. It is also worth noting that this period life expectancy is only a summary measure of current age-specific mortality conditions and does not give the cohort life expectancy that e.g. a newborn today would be expected to live if mortality conditions continued to improve.

While it seems evident that being alive is a necessary precondition for enjoying any quality of life, many of the most common indicators do not reflect this most fundamental fact. They tend to focus only on those people who are still alive at any point in time and evidently consider death as something natural that need not be reflected in the indicator. But this can lead to absurd conclusions in the case of some discontinuities in mortality conditions. In Botswana, a country particularly hard hit by the AIDS pandemic and with an economy largely based on diamonds, the massive increase in AIDS mortality has led to an increase in GDP per person because the diamond sales were hardly affected by those deaths whereas the population size used in the denominator was shrinking (Basdevant 2008; Hillbom 2008). This massive increase in premature mortality could hardly be interpreted as an increase in well-being. The same problem arises in the case of differential mortality. If those in poverty or those with low levels of happiness have higher mortality rates – which is typically the case – and the two groups are independent then this higher mortality of the miserable tends to increase the average income or happiness of the surviving. This selection process again should not be interpreted as a real increase in average well-being over time. Rather the length of life and the incidence of premature mortality should be directly factored into the well-being indicator.

Conceptually, the notions of premature death and average length of life are not identical. Premature death has the connotation of something that could be potentially avoided while it is not clear whether total life expectancy could continue to expand. The notion of premature death is also determined by two different factors: The inequality of mortality with always some people dying before the average of dying, and the maximum achievable average life expectancy due to the state of medicine at any point in time. The HDI tries to address the second issue by viewing the life expectancy of every country relative to the country with the highest life expectancy in the same period presumably under the assumption that this is best practice that could possibly be achieved by every country. But this does not consider the drivers of life expectancy that cannot be influenced – such as cohort effects – and in particular it makes it impossible to compare the HDI over time. The other issue relating to the inequality in mortality including the fact that not everybody dies at the same age and some inevitably die before the mean age of death has not been addressed – and would be difficult to address – by any well-being indicator to our knowledge.

For these reasons YoGL will use period life expectancy in its absolute value (mean years of life expected under current mortality conditions) as the basis for further calculations. Since typically increases in average length of life are strongly associated with avoidance of premature mortality, particularly among children, this indicator seems to be a good summary measure of survival conditions in general in the chosen (sub-)population.

Finally, if we accept the view that survival is a basic prerequisite for all other dimensions of quality of life, this also rules out a design of the indicator where survival is combined with other dimensions on equal basis and weighted in its relative importance using some more or less arbitrary weight. The HDI gives the relative life expectancy index a third of the weight with GDP and education both getting equal weight. Hence, in the hypothetical case of a major disaster killing many people and in particular the poor and uneducated, the HDI could still show rather high values. As to the OECD Better Life Index, life expectancy is one of two health indicators and health is only one of eleven domains. Hence, given the suggested default of equal weighting even a hypothetically disaster or disease that kills large proportions of the population would only have a very marginal effect on the Better Life Index.

While such a marginal effect of the most fundamental prerequisite for enjoying any quality of life and also avoiding the premature death of your family members – something that tends to have the highest personal priority including willingness to pay in economic terms – is problematic for any well-

being indicator it is particularly inappropriate for an indicator that is supposed to relate to sustainable development and also capture the effects of possible major disasters and other high impact problems resulting from environmental change. For this reason length of life was chosen as the all decisive first level criterion for YoGL with the following levels only addressing the question to what extent the total years of life are actually years of good life.

2. Capable longevity

We have argued above that being alive is a basic prerequisite for enjoying any quality of life and therefore needs to be the backbone of any indicator that should meet the six specified criteria including its fit for being used as an indicator for assessing long-term sustainable well-being. A focus on survival as the key element of W – the well-being indicator on the left side of the equation – also has the advantage that there can be no doubt that this qualifies as an ultimate end. It is not a capital or an intermediate end or means that should be on the right-hand side of the equation but the ultimate outcome. When death comes, it is over – at least with respect to life on this earth.

Mere survival at the same time cannot be the ultimate end for life on earth. All cultures tend to believe that there must be more to it. But what is this more? There clearly is a subjective element to it with different people valuing different aspects of life differently and there are also some differences among the cultures in which individuals are embedded. In other words, while it can be argued that avoidance of premature death of oneself and of the people one cares for is a universally shared value there seems to be less consensus as to what constitutes a good life. For this reason, the literature on the topic suggests that any indicator covering the topic of good life must have a subjective dimension. Only people themselves can judge whether they are satisfied with their lives according to whatever are their own criteria. That is why subjective life satisfaction is a constituent element of YoGL to be discussed in the next section.

Yet, the vast literature on well-being also suggests that there are also some objective preconditions and dimensions of what constitutes a good life that can be assessed independently from subjective life satisfaction. In particular, the highly influential writings by Martha Nussbaum and Amartya Sen have approached this issue by identifying basic capabilities to characterize a good and successful life. In some early writings of Sen and colleagues on indices of well-being (Desai et al. 1992) there was a discussion about which are the most fundamental objective aspects of capability and empowerment. They identify basic health, some basic material subsistence level and cognitive functioning and empowerment as the three areas that jointly determine a person's capability, which can also be viewed as the freedom to achieve well-being. This general approach has then prominently been translated into the HDI whose three components (health, income and education) directly reflect the three aspects of capability. Nussbaum and Sen even suggest to combine these three dimensions with longevity to produce an indicator called "capable longevity" (Kelley 1991). This is directly in line with the approach chosen for YoGL.

Following the first of the above described criteria the indicator should be based on measurable individual characteristics. In addition, because of our clear distinction between subjective and objective dimensions of good life years, the characteristic chosen for this objective capabilities aspect of the indicator should be as objective as possible and avoid personal assessments such as subjective health status and even personal statements about conditions that are theoretically observable but not tested in the interviews collecting this information. An example for the latter is, if people are asked whether they can walk 5 kilometers but this is not being tested.

For these reasons we chose to do the preliminary analysis with the following items that are assessed in international surveys for covering the three domains of capable longevity:

Being out of absolute poverty, which in low and middle-income countries is being assessed through the presence of certain facilities such a flush toilet or a solid floor in the living room. In high-income countries is being assessed through household consumption data.

Being able to read and comprehend a sentence are part of the cognitive capability indicator. It is being assessed through a standardized test of basic literacy (Soler-Hampejseka et al. 2018).

Having no severe activity limitation is being assessed with respect to difficulties in Activities of Daily Living (ADLs) and specifically through testing the difficulty in rising from a chair (Alexander et al. 1991), which can be objectively verified. Additionally, the General Activity Limitation (GALI) question is considered a proxy for measuring disability as the respondent answers one question about limitations on activities of daily living in the past six months (Berger et al. 2015).

3. Overall life satisfaction

The literature on subjective indicators to measure well-being (or subjective well-being) is rapidly increasing and attracts more and more attention even among quantitative social scientists and policy makers, with an average of 14,000 publications a year (Diener et al. 2017). A review of this extensive literature relevant for the development of YoGL as well-being indicator is given elsewhere (Lijadi 2018). The most widely recognized scales to measure subjective well-being are the one single item of the Life Satisfaction Scale by Diener (Diener 1984; Diener et al. 1985) and the one single item of Happiness scale (Bradburn 1969), which are used in reputable international surveys such as World Value Survey and the European Social Survey, among a few.

The literature suggests some caution when using the concept of “happiness” as to whether the concept has the same meaning across culture and time (Carlquist et al. 2017), and whether there are notable differences in how people present themselves and response styles (Diener et al. 2017; Oishi 2010). The concept of “happiness” tends to have different meaning in different languages, to be more volatile and directly dependent on emotions (Delle Fave et al. 2011; Mogilner et al. 2011). Moreover, the European Social Survey revealed that people answer differently and inconsistently when they were being asked ”Thinking of your life in general, are you happy?” or “Thinking of your life in general are you satisfied with your life” (Becchetti & Conzo 2017).

Here it suffices to say that we decided to go for the one item life satisfaction scale that tends to show strong consistency and less variability over time when repeatedly assessed for the same person (Becchetti & Conzo 2017). The life satisfaction scale has been developed to evaluate satisfaction with the respondent’s life as a whole. The scale does not assess satisfaction with various life domains (such as health, work, education, social capital or wealth) but allows participants to integrate and weight these domains in whatever way they choose, and has shown validity across age, gender and culture (Arrindell et al. 1999; Di Fabio & Gori 2016; Jovanović 2017; Tomás et al. 2015). We intentionally decided not to focus on satisfaction with respect to more specific domains of life because we wanted to have one comprehensive indicator. While it is possible that some important aspects have been left out when asking for overall life satisfaction, it still is the most authentic assessment including the implicit weighting of different domains by the responded him/herself. It is also worth noting that this broad definition of life satisfaction is also assumed to cover the possible impacts of experienced inequality (see the works of Schwarze & Härpfer 2007 using German Socio-Economic Panel Study 1985-1998; Veenhoven 2005 with EU countries 1973-2001; Verme 2011 using European

and World value survey 1981-2004). This implies that if a person experiences inequality as negative – through a wide range of possible mechanisms ranging from being envious to the richer neighbor or experiencing more crime – this should be reflected in the overall satisfaction score.

A specific important aspect of human well-being and life satisfaction is the embeddedness in social networks and support structures. In her social well-being theory, Keyes (1998) pointed out that well-being is "the appraisal of one's circumstance and functioning in society; in which individuals remain embedded in social structures and communities, and face countless social tasks and challenges"(p122). This is something that many people experience and value as an essential contributor of quality of life and that has been labelled as social capital. The importance of social capital to well-being is reflected in companionship, emotional support, social approval, solidarity, a sense of belonging and of experiencing one's history, and the desire to be loved or recognized by others (Bartolini et al. 2017). The OECD and the World Happiness Report measure social capital by number of friends, participation in groups and associations, attendance to social gatherings and general trust (Almakaeva et al. 2017; Hamilton et al. 2016; Helliwell et al. 2014). Attempts to measure social capital through the number of Facebook friends or the number of associations a person belongs to have not been very successful in part because they do not distinguish between quantity and quality of contacts (Castellacci & Tveito 2018; Guo et al. 2014). Scholars also warn about the consequences of replacing traditional methods of communication with social networking sites due to different personal motivation (Bozoglan 2018; Huang 2017; Sinche et al. 2017). Despite the booming usage of social networking sites, face to face communication is still deemed to be the most effective way to lower loneliness and increase life satisfaction (O'Brien et al. 2017; Wohn et al. 2017). Another approach to measuring social capital is focusing on general trust, i.e. asking people whether they in general trust others. The answers to such questions show very strong variation across cultures and countries (Wahl 2014).

It is not clear whether in the context of YoGL, the social capital should be treated as an ultimate end indicator or as variable contributing to the production of well-being. Already the label as social capital suggests that it might belong to the right hand side of the equation together with all the other capitals. Furthermore, there tend to be strong individual variations about the intensity of social networks deemed desirable by different people. Taken together, these arguments suggest that it is defendable and pragmatic solution to assume that the broad general question on life satisfaction also includes a self-weighted assessment of the satisfaction with one's own social network.

How to calculate YoGL based on a life table

To calculate YoGL, we apply the well-established method first proposed by Sullivan (1971). Although the method was originally intended to provide a single indicator of mortality and morbidity, it can be applied to any number of social phenomena. Sullivan's method has been successfully applied in calculating indices of well being (Perenboom et al. 2004), as well as healthy (Imai & Soneji 2007) and happy life expectancy (Yang 2008). The only requirement the phenomenon of interest has to fulfill is that it allows for the quantification of proportions of the population in different states. In the case of YoGL, the state space includes different levels of subjective satisfaction with life, as well as the objectively assessed states of poverty, literacy, and health. Baring a large enough sample population, the proportions of people in different states can be calculated at different ages before using them as weights for the age-specific life table person years lived (L_x), from which life expectancies in different states can be obtained using conventional life table techniques.

In more formalized notation, Sullivan's method can be described in the following way: Suppose for a specific time period we have survey information regarding a state of interest for a sample of

individuals subdivided into different age groups ranging from $i = 0\ to\ A$, as well as life table information on the number of survivors at the beginning of each of those age brackets and the number of person years lived within them it can be applied using a life table. Using common life table notation, let:

$$l_i = number\ of\ survivors\ at\ age\ x_i\ (beginning\ of\ the\ interval\ i)$$

$$L_i = number\ of\ person\ years\ lived\ in\ the\ age\ group\ i$$

$$\pi_i = prevalence\ of\ the\ state\ of\ interest.$$

Then Sullivan's indicator, summarizing all the information above by a single number interpretable as the number of years a member of that sample population can expect to live in the state of interest independently of the sample's age structure, can be derived as:

$$\frac{1}{l_0}\sum_{i=0}^{A} \pi_i\, L_i.$$

Table 1 gives an example of calculating YoGL based on life table information for the general female population of the Philippines interpolated for 2014, combined with information from a survey of Philippine women conducted in the same year (Hoffmann & Muttarak 2017) which includes the four dimensions of YoGL. Due to the small sample size, the life table needs to be truncated above the age of 60. The life table provides the information on the women surviving to each age for that period (l_i) as well as the number of person years lived in each age group by Philippine women (L_i). Starting with this information, we can derive conventional T_i as the number of person years lived by the general female population of the Philippines beyond age i. Yet, rather than counting each person year equally, we distinguish good years from bad years weighing them by π_i, the proportion of women within the survey that reported to be satisfied with their lives, out of poverty, literate and without health limitations. This gives us the pL_i column, which can finally be divided by l_i to give us the number of years of good life ($YoGL_i$) the women in this sub-sample can expect to live beyond age i. If age specific mortality conditions, as well as the life circumstances assessed by the survey in 2014 persist over their entire lifetime, 20 year old Philippine women in the survey population can expect to live 41.8 good years out of a total of 54.9 years (E_i).

When it comes to the empirical estimation of YoGL there are so far not many survey data that for the same individuals give reliable information for all four dimensions of YoGL (subjective life satisfaction, being out of poverty, being not disabled and being cognitively able to read). The broadest survey data with all this information is in the set of SHARE surveys for female population aged 50 years and above for 17 countries. Another survey including all this data for women from age 20 onwards is from the Philippines. If different sub-samples of the population are drawn, the values of Sullivan's indicator for each of those sub-samples can be directly compared, giving us an idea of how much worse or better off specific groups within a society are. In addition, Sullivan's indicator can be calculated at the beginning of any age group in the life table if age-specific information on the four component indicators of YoGL is available. The SHARE survey (Börsch-Supan 2018), for example, is representative only for the population above the age of 50. So rather than starting at age 20, the life table used in this exercise starts at age 50. We can use the following variables available in SHARE to construct YoGL: For the subjective dimension, we use the survey item on life satisfaction with

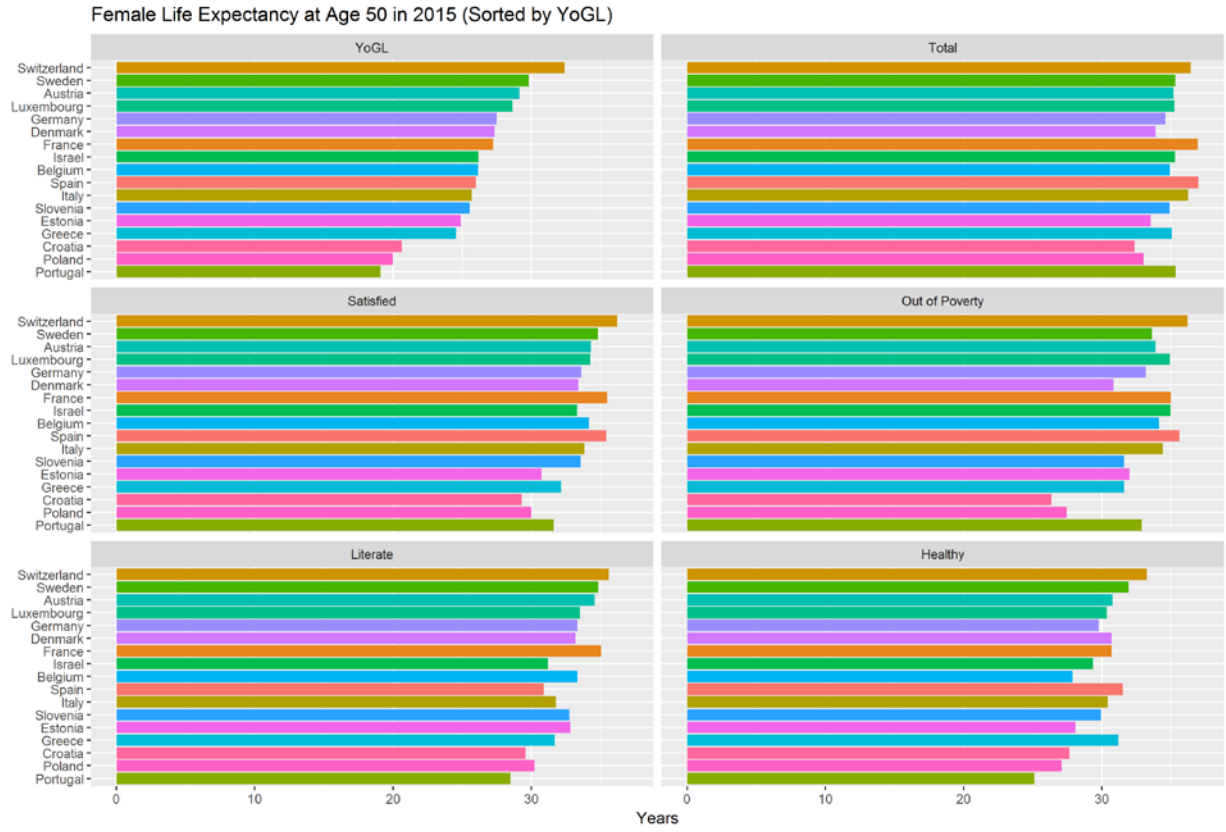
possible answers ranging from 0 to 10. The cut-off line is drawn at 4, meaning that all respondents who report life satisfaction higher than 4 score positively on the subjective dimension. Regarding the three objective dimensions, respondents are considered to be out of poverty based on the World Bank poverty line for upper-middle income countries if their equivalized consumption expenditure is higher than 5.50 US$ (PPP) a day. Respondents who have "poor" reading or writing skills are considered illiterate, and those with "fair" and above skills are considered literate. For health, individuals who have one or more limitations in ADLs are considered to be in bad health and those with no limitation are considered in good health.

Table 1: Example life table for calculation of Years of Good Life (YoGL), Philippine females, 2014. Source: Hoffmann and Muttarak (2017) **and UN** (2017)**.**

Age	l_i	L_i	T_i	π_i	pL_i	pT_i	E_i	$YoGL_i$
20	97038	484338	5323595	0.84	407863	4051990	54.9	41.8
25	96679	482341	4839257	0.84	406182	3644126	50.1	37.7
30	96234	479600	4356916	0.77	370126	3237945	45.3	33.6
35	95564	475593	3877316	0.78	371353	2867818	40.6	30.0
40	94615	469815	3401723	0.83	388501	2496465	36.0	26.4
45	93223	461376	2931908	0.80	368460	2107964	31.5	22.6
50	91196	448876	2470532	0.75	338194	1739504	27.1	19.1
55	88178	431287	2021656	0.71	305722	1401310	22.9	15.9
60+	84091	1590369	1590369	0.69	1095588	1095588	18.9	13.0

Figure 2 applies the methodology described earlier for the Philippines to all countries available in wave 6 of the SHARE survey. The countries are displayed in descending order of "YoGL" in the upper left panel, with Switzerland leading the ranking and Portugal scoring lowest. Interestingly, the ranking would be very different if countries were sorted by life expectancy ("Total") in the upper right panel. Here it is Spain that leads the ranking, with Portugal and other Mediterranean countries following closely behind. So clearly, despite the strong influence of life expectancy on YoGL, the two indicators are not measuring the same.

Figure 2: Life expectancy at age 50 in 2015 by country. Order of countries determined by "Total" life expectancy ranging from top left (Spain) to bottom right (Croatia). Source: SHARE (Börsch-Supan 2018) and UN (2017).



Moreover, Figure 2 shows how individual components of YoGL contribute to the difference between life expectancy and YoGL. In order to contribute a full YoGL to the total number of good person years lived, an individual needs to score positively in all four dimensions of YoGL. As some individuals score positively in one dimension of YoGL while scoring negatively in others, YoGL is typically lower than the lowest number of years people can expect to live in any one of the four contributing component states of being either "Satisfied", "Out of Poverty", "Literate" or "Healthy". Notably, different countries lose YoGL for different reasons: While in most countries the primary reason is the health dimension, in Spain it is the number of literate life years that is even lower than the number of healthy life years, whereas in Croatia it is the number years one can expect to live out of poverty. In all countries available, respondents report to be more satisfied with their lives than their health status would suggest. This difference is most pronounced in Portugal where on average it amounts to almost 6.5 years of life.

Comparing YoGL to selected other well-being indicators

Over the last few decades, we have witnessed the development of many indices of well-being, which aim to provide regional and global snapshots of the state of human well-being at the national level. One of the earliest well-being indices is the Physical Quality of Life Index (PQLI) (Morris 1980), which can be regarded as an improvement from using GDP, as the index provides progress in health, education and women's status. The PQLI uses a life expectancy indicator (a combination of life expectancy at age 1 and the infant mortality rate) to represent health, and the basic literacy rate (based on the percentage of the population that completed at least primary school) as indicator of development, all equally weighted on a 0 to 100 scale without any theoretical underpinning. One criticism of PQLI regards the health dimension, as infant mortality and life expectancy are obviously strongly correlated. Every surviving child adds a large number of years to the number of person years lived by the population, thus reductions in infant mortality will result in increases in life expectancy. Hence, including both life expectancy and infant mortality in the health dimension of the PQLI can be considered double-counting.

Following the PQLI, further indices have been developed, relying on theoretical frameworks which aim to capture a more holistic picture of well-being by considering social and environmental issues alongside economics (Döpke et al. 2017; Menegaki & Tugcu 2017; Michalos 2017). In the following, we choose and compare indices which are developed (1) to cover as many countries in the world as possible, namely the Human Development Index (HDI), the Well-being of Nations Index (WBI), the Sustainable Society Index (SSI), the Happy Planet Index (HPI), the Better Life Index, the Social Progress Index, and the Composite Global Well-Being Index (CGWBI); and indices trying to measure (2) multidimensional well-being within one country, namely: The Gross National Happiness Index (GNH Bhutan), the Canadian Well-being Index (CWI Canada), and the Gross National of Wellbeing (GNW USA). A summary comparison of these indices is presented in Table 2.

We compare YoGL to 10 other selected indicators and assess their theoretical frameworks, the development of the indices, the choice of indicator components and calculation method, as well as the quality of data used to construct the index. We pay attention to the way the indices adjust their specification to specific aspects of industrialized and developing countries (Strezov et al. 2016) as well as to distinct characteristics of individual countries (Holden et al. 2017; McLean 2017; Rodríguez-Rosa et al. 2017).

Theoretical framework of the indices

The theoretical frameworks behind existing indices often accumulate multidisciplinary approaches; such as the well-lived life or hedonic approach (Kahneman & Krueger 2006; Layard 2010), the Quality of Life theory which builds on the capability approach (Nussbaum & Sen 1993; Gaertner 1993), subjective well-being (Diener 1984), the self-determination theory (Ryan & Deci 2011), and positive psychology (Seligman & Csikszentmihalyi 2014), to name just a few. Sociologists tend to conceptualize quality of life as the interplay of human beings with each other and within the social context that they live in (Bárcena-Martín et al. 2017; Puntscher et al. 2015; Veenhoven 2013). Environmentalists, on the other hand, emphasize the importance of awareness of sustainable interactions between an individual and their social and physical environment (Knoop & Delle-Fave 2013).

Some indices are constructed adopting all the above theories (i.e., the OECD Better Life Index, the Well-being of Nations index, GNH, and CWI) and some incorporate only one or two theories (i.e., the HPI only considers ecological footprint and satisfaction score). The dimension of social connection is

adopted in the Better Life Index, WBI, SSI, CGWBI as well as in the CWI Canada and the GNH Bhutan.

Like YoGL, the HDI is developed based on the capability approach, stating that people and their capabilities, together with economic growth, are vital determinants in assessing a country's state of development. The HDI integrates three equally-weighted concepts: (1) long and healthy life (measured by life expectancy, (2) knowledge (measured by people's ability to empower themselves through education), and (3) a decent standard of living (measured by GDP per capita). A completely different approach is pursued by the HPI. It incorporates environmental impact (based on the natural resources that are needed for a person to live) and life satisfaction (based on the subjective evaluation of one's overall satisfaction with life) to measure the ecological efficiency with which human well-being is delivered around the world. Thus both the HDI and HPI use indicators of ultimate ends rather than means to achieve those ends.

The Wellbeing of Nations index incorporates the Bellagio Principle (Bakkes 2012), which gives guidelines for assessing progress toward sustainable development at the global and national level, including the choice and design of indicators, the interpretation and communication of results. According to the Bellagio Principle, an index should be composed by interrelated indicators that function as a complete set in assessing activities of community groups, non-government organizations, corporations, national governments, and international institutions (Pintér et al. 2012). Thus for an index to be able to measure sustainable development, it needs to include the environmental costs of human activity, not only the economic output or the social well-being derived. The Wellbeing of Nations index also claims that people are both emotional and physical, social and individual, thus it is essential for the index to cover as many human dimensions as possible, such as self-expression (under Knowledge and Culture dimension), human right (under Community dimension), and social freedom (under Community dimension).

The SSI is constructed based on a definition of sustainability by the Brundtland Report (WCED 1987). A sustainability society by SSI means a society that meets the needs of the present generation, without compromising the ability of future generations to meet their own needs; and in which each human being has the opportunity to develop themselves in freedom, within a well-balanced community and in harmony with their surroundings (Saisana & Philippas 2012; Van de Kerk & Manuel 2008). The selection of indicators in the SSI are based on the following criteria: The indicator must be relevant for an issue according to the definition used; measurable; independent from each other and no mutual overlap; data for the indicators must be reliable, recent and regularly updated, and available from public sources, scientific or institutional, for all countries. To ensure transparency, the set of indicators has to be easily accessible, also for the general public. This means that the number of indicators must be limited; cover the whole field of sustainability and give a good insight into the present situation with respect to sustainability. The SSI can indicate the gap between the present situations to the situation of complete sustainability; and is comparable between countries. Ideally in a sustainable society, the country is able to develop itself in a healthy manner and to obtain proper education, lives in a clean environment, lives in a well-balanced and safe society, and uses non-renewable resources responsibly.

Building on the recommendation to measure well-being and progress by the Stiglitz-Sen report (2010), the OECD developed the Better Life Index to measure the economic condition and the quality of life of people around the world. The index has 11 topics, include: Housing, income, job, education, health, environment, community, civic engagement, safety, work-life balance, and life satisfaction. The first three topics make up the material conditions of well-being, while the remaining eight represent the quality of life. In 2011, the first Better Life Index report the progress of 35 countries

(22 countries are member of the EU), which include both objective and subjective aspects, averages and inequalities, and capture the present and future quality of life. The main innovation of the Better Life Index is the interactive website, which allows users to create their own composite index, i.e. assign a weight to each of the 11 dimensions of the OECD well-being framework. Users can compare the average index to their own personal index.

The Composite Global Well-being Index simply adopted OECD's Better Life Index approach and extend the coverage to include more countries (124 countries as of 2016) with using internationally available data. The HPI and the SPI are the two indices that not include economic indicator. The HPI claims that the index measures sustainable well-being taking into consideration of resources, human systems and well-being factor. The HPI uses data on life expectancy (UNDP Human development's report on the number of years an infant born in a country could expect to live, given prevailing age-specific mortality rates at the time of birth stay constant throughout an infant's life), experienced well-being (data from the Gallup World Poll on Life evaluation), and the =Ecological Footprint (data of sustainability of resource consumption within countries). Experienced well-being is multiplied with life expectancy and then divided by the Ecological Footprint to achieve a ranking of how many long and happy lives countries produce per unit of environmental output.

The SPI gives focus to opportunity that is available within a country to meet the basic human needs of its citizens, and whether the country has the conditions for all individuals to reach their full potential and to enhance and sustain the quality of their lives. To serve the purpose, the SPI includes indicators such as access to basic knowledge, access to information and communications, personal rights, freedom and choice, etc.

Intrinsic consideration

We noticed that all indices were developed to show a meaningful development of a country beyond the fulfilment of material satisfaction. Attention is mainly on measuring development, with some indices also taking social, political and environmental factors into consideration. The Better Life Index provides information on how community and civic engagement affect one's well-being. Our communities are filled with diverse individuals and diverse groups of residents who, though they share a common place, may not experience their communities in exactly the same way as their fellow community members (Talmage & Knopf 2017). Citizens expect their government to take a major role in enhancing quality of life by imposing rules and policies in solving national problems. The trust and conformity by the citizens to their government is measured by support for elections (such as voting), poverty index, availability and access to public facilities, and nationalism (such as participation in national day).

Hence, we noticed that among the 10 indices being evaluated, only CWI Canada and GNH Bhutan were developed by reflecting the normative values which are embedded in the culture and traditions of a particular country. The GNW USA treats well-being as a socioeconomic development metric, which measures the socioeconomic development in seven areas, including nation's mental and emotional health.

Other indices aim to cover as many countries as possible, thus they are developed with the assumption that all factors included in the indicators selection are equally significant in every country. As a result, there is an inconsistency and unexplainable phenomenon in world-wide comparison. For example: The 2012 HPI report showed that Costa Rica, Vietnam and Colombia are the top three happiest countries (Abdallah et al. 2012), while the 2013 HDI report showed that the same three countries performed poorly in human development (Costa Rica is at ranking 62, Vietnam at 127 and

Colombia at 91). Variance on the ranking from various indices raise confusion about where the happiest or best place to live actually is, or who the happiest people are that are enjoying the best quality of life on the planet. How can we explain that countries which are less progressing in human development actually show better results in managing their energy consumption and act more sustainable to their environment, compared to countries that show a tremendous progress in improving their population in education, health and awareness to their environment?

We also noticed that in order to serve different purposes, some indices are hoarded with large numbers of indicators with a combined means and ends indicator (Meadows 1998). The HDI and HPI are the only indices that employ ultimate ends indicators. The HDI include indicators of knowledge, health (life expectancy) and decent living. The HPI includes indicators of resources Ecological Footprint, human systems (life expectancy) and well-being. The GWB USA is the only index using subjective responses (ultimate ends) to all its seven dimensions, and yet, it raises the question of how to weight each dimension. Will physical and health well-being be weighted equally with political and government well-being? Other indices mix both ultimate means and ends indicators. For example: Well-being of Nations and the Sustainable Society Index include ecosystem or environmental well-being (both are ultimate means indicator) in their formulation as well as GDP (ultimate ends indicator). The Better Life Index combines ultimate means (i.e., environment), intermediate ends (i.e., housing, work life balance, job), and ultimate ends (i.e., income, health, life satisfaction).

Individual vs. national data sources

Among the worldwide covered indices, we observed different ways of gathering data. The Better Life Index stipulates that each indicator must be relevant to the dimension being measured and using data from well-established sources with standardised definition to cover as many countries as possible. The data should be collected over times series and with the possibility to disaggregate by population sub-groups. The SSI employed a top-bottom approach, looking at national representative data – instead of individual data – with the intention to have an index that can be used at national and international level. The SSI claims that each country will likely add one or more tailor-made indicators within its own sustainable criteria to cover the country-specific circumstances or issues. Originally the SSI – as per 2006 report consists of five dimensions (personal development, clean environment, well-balanced society, sustainable use of resources and sustainable world) which are further divided into 22 indicators (Van de Kerk & Manuel 2008). In 2012, the SSI has been revised to include three main dimensions: Human well-being, environmental well-being and economic well-being, which are further divided into seven categories and 21 indicators.

Except for GNH Bhutan, GNW USA and CWI Canada (indices that were developed solely for measuring nation-wide well-being), indices use available international data source, combining aggregate national data for each indicators. The Wellbeing of Nations index, which attempted to cover the most important aspects of humans and their environment, gathered data from numerous international data resources (i.e., WHO, UNESCO, FAO, UNDP, World Bank, IMF, UNESCO, United Nations Crime Prevention and Criminal Justice Division, Eurostat, Asian Bureau for Conservation & World Conservation Monitoring Centre, etc.). The HPI uses data from the Gallup World Poll for life satisfaction, United Nation for life expectancy, and Ecological Footprint for the average impact of each resident of a country on the environment. Other indices, such as the SSI, SPI, and CGWI follow the same data mining. The Better Life Index are using data from the OECD database as well as other international data sources, include the life evaluation data from the Gallup Poll.

The limitation of not collecting individual data is that the indices can only report a national performance at certain time but not the progress over time. The indices are unable to give an accurate representation of how well-being is increasing or evolving in different regions over time and among different groups.

Calculating the indices

Each index has a set of formulas, assumptions and aggregations to calculate the indicators. The HDI gave equal weight to its indicators, and initiated the creation of a single statistic that serves as a frame of reference for both social and economic development. The HDI sets a minimum and a maximum for each dimension, a.k.a. goalposts, and then shows where each country stands in relation to these goalposts, expressed as a value between 0 and 1.

The Wellbeing of Nations uses the intersection between its two main dimensions – human well-being and ecosystem well-being – as their index measurement. The human well-being is calculated based on the lower of either four unweighted average of human dimensions (with or without equity), ranging from 0 to 100 or bad, poor, medium, fair and good. The equity index measures the distribution of wealth and other benefits within the general population of a country (household equity) and between males and females (gender equity). In some countries, wealth is unevenly distributed, equity therefore is included in the calculation of human well-being to give a more realistic picture of national conditions. The ecosystem well-being is calculated based on the lower of either four unweighted average of all ecosystem dimension (with or without resources use), also ranging from 0 to 100 or bad, poor, medium, fair and good. The resource use indicators are part of the consumption process whose impact in the ecosystem may not be adequately covered by other dimension, hence they are sometimes include and sometimes excluded in the resources use dimension. By plotting the human well-being in the vertical-axis and the Ecosystem well-being in the horizontal-axis of a chart, the well-being of a nation index is defined by the point where the human well-being and the Ecosystem well-being is intersect –so called the Barometer of Sustainability. The well-being stress index measures the ratio of human well-being to the ecosystem stress, which shows how much human well-being each nation obtains for the amount of ecosystem stress it causes.

The SSI uses the most recent public data sources (for example FAO, UNESCO, World Bank, Aquastat, Global footprint, etc.) and is updated every two years. As of 2016, SSI covers 154 countries, comprising 99% of the world population. There is no scientific basis for the attribution of different weights to the indicators; every indicator has received the same weight for the aggregation into dimensions. The latest report indicates a negative correlation between human and environmental well-being, which prevents the SSI from being aggregated from the dimension level into one single overall index (Van de Kerk 2015). The 2016 report also shows that higher GDP leads to higher human well-being, but worse environmental well-being and an increasing population size.

The HPI is calculated by multiplying life satisfaction, life expectancy and its inequality of outcome (percentage of life expectancy and life satisfaction) over the ecological footprint. The Ecological footprint measures the ecological assets that a given population requires to produce the natural resources it consumes. One noticeable challenge in measuring an indicator for well-being is that with times, and over a long period, some indicators are no longer relevant, or the data collection method changed. For example, some data on natural consumptions (especially in developing countries or less industrial countries) are not applicable to some countries. A good solution will be to focus primarily on long-term indicators that can be measured in time series (Boelhouwer 2017).

Analogue to real life interpretation

What does it mean for Austria to have a HDI of 0.893 (ranking 24), a HPI of 30.5 (ranking 43) and an SPI of 87.98 (ranking 14)? How about for Norway with a HDI of 0.949 (ranking 1), a HPI of 36.8 (ranking 12) and an SPI of 90.27 (ranking 3)? All these numbers need to be interpreted within the framework and the dimensions of the index. The Better Life Index does not attempt to come with one number, simply because the OECD is fully aware of the significant differences between each country in all life domains (economic, social, politics, culture and values), thus the index does not try to give the equal weight to its dimensions.

Given the complex, multidimensional nature of well-being, it is hardly surprising that these indices differ in terms of purpose and how they are constructed. While many of them show a strong degree of transparency and are found to be relatively concise (Böhringer & Jochem 2007), none of them provides a simple interpretation or good analogue such as GDP. People can understand easily what it means to have a dollar in the pocket, but not an index of HDI 0.893.

Our new indicator, the YoGL gives an easy interpretation of the index. YoGL of 75 at birth means that the person has a chance of 75 year of good life: Out of poverty, able to read and write, in a good mental and physical shape, and overall satisfied with his or her life.

Table 2: Comparison of Selected Human Well-being Indices

Index Name	Agency or Author(s)	Theoretical Framework	Indicators	Coverage	Data Source	Index Calculation	Indigenous consideration
Human Development Index (HDI)	UNDP http://hdr.undp.org/en/content/human-development-index-hdi	Capability Approach (Sen)	1. Life expectancy at birth 2. Average of mean years of schooling for adults aged >20 years, and expected year of schooling for children of school entering age 3. GNI/capita	1. Annual since 1980 2. 188 countries as of 2017	Data from international and reputable organization, include: UN Population Division in UNDESA, UNESCO Institute for Statistics, World Bank and IMF	• Equal-weighted Geometric means of three dimensions • HDI index vary from 0 to 1	• Nil • Consideration was given to the GNI, the minimum is US$100, and the maximum is US$75k per capita
Well-being of Nations One report in 2001	World Conversation Union & International Development Research Centre (IDRC), Canada https://www.idrc.ca/	• Bellagio principle • Quality of life is measured through the interaction between human and their environment	Human well-being (HWI) 1. Health 2. Wealth 3. Knowledge & Culture 4. Community 5. Equity Ecosystem well-being (EWI) 6. Land 7. Water 8. Air 9. Species & genes 10. Resource use Wellbeing Index juxtaposes HWI and EWI Wellbeing/Stress Index (WSI) shows how much human well-being each nation obtains for the	1. Only one report in 2001 2. 183 countries in 2001 3. Exclude subjective well-being dimension	Data from international and reputable organization, include: International database 1972-2001, includes WHO, UNESCO, FAO, UNDP, World Bank, IMF, UNESCO, Freedom House, Transparency International, United Nations Crime Prevention and Criminal Justice Division, Canadian Centre for Justice Statistics, FBI, Eurostat, Asian Bureau for Conservation & World Conservation Monitoring Centre, United Nations Statistical Commission & Economic Commission for Europe, IUCN World Commission on Protected Areas, World Conservation Monitoring Centre, GLASOD—the Global Assessment of the Status of Human-induced Soil Degradation, World Energy Council, National Water Research Institute, Global Environmental Monitoring System (GEMS), Carbon Dioxide, Information Analysis Center (CDIAC), OECD, UNEP World	• Equal-weighted of HWI and EWI dimensions • The Wellbeing Index is the point on the Barometer of Sustainability where the HWI and the EWI intersect • The Wellbeing/ Stress Index (WSI) measures the ratio of human wellbeing to ecosystem stress.	• Nil • Consideration for HWI was given to a country with low equity • Consideration was given to country without resources use

Index Name	Agency or Author(s)	Theoretical Framework	Indicators	Coverage	Data Source	Index Calculation	Indigenous consideration
			amount of ecosystem stress it causes		Conservation Monitoring Centre Threatened Plants Database (WCMC), IUCN Species Survival Commission, United Nations Energy Statistics Unit, FAO Marine Resources Service, Fishery Resources Division	• Well-being of Nations index is from 0-100	
Sustainable Society Index (SSI)	Sustainable Society foundation of the Netherlands http://www.ssfindex.com/ssi/	• Brundtland Report on Sustainable society approach	**Human well-being** • Basic Needs 1. Sufficient Food 2. Sufficient to drink 3. Safe sanitation • Personal Development and health 4. Education 5. Healthy Life 6. Gender Equality • Well-balanced society 7. Income Distribution 8. Population Growth 9. Good governance **Environmental well-being** • Natural Resources 10. Biodiversity 11. Renewable water resources 12. Consumption • Climate & Energy 13. Energy Use 14. Energy Savings 15. Greenhouse Gases 16. Renewable Energy	• Bi-annual since 2006 • 154 countries as of 2016) • Excluded subjective well-being	Data from international and reputable organization: FAO, UNESCO, World Bank, World Economic Forum, Population growth database, UNEP-WCMC, Aquastat, Global Footprint network for consumption, Renewable energy from IEA, Organic farm from FiBL, ILO, IMF World Economic Outloook	• Equal-weighted Geometric means of three main dimensions • SSI is from 0-10	Nil, with the consideration that each country might one to add its own unique indicator that importance in the country.

Index Name	Agency or Author(s)	Theoretical Framework	Indicators	Coverage	Data Source	Index Calculation	Indigenous consideration
			Economic well-being • Transition 17. Organic Farm 18. Genuine Saving • Economy 19. GDP 20. Employment 21. Public debt				
Happy Planet Index	New Economics Foundation http://www.happyplanetindex.org	Efficiency of consumption natural resources may lead to long, happy, sustainable lives	1. Ecological Footprint 2. Well-being (life evaluation) 3. Life expectancy	1. Every 3 years, since 2006 2. 151 countries as of 2012	Data from international reputable organization: Global footprint network, Gallup World Poll and United Nations	• HPI=Well-being x Life expectancy x Inequality of outcome / Ecological Footprint Inequality of outcome= % of life expectancy and well-being	Nil
Gross National Happiness	Centre for Bhutan Studies &Oxford University	To measure the collective happiness and well-being of a population	1. Psychological well-being 2. Health 3. Time use 4. Education 5. Cultural diversity and resilience 6. Good governance 7. Community vitality 8. Ecological diversity and resilience 9. Living standards	1. Since 200 2. Only for Bhutan 3. Irregular report, so far 2012, and 2015	Survey data by Centre Bhutan Studies	• Each dimensions is composed of subjective (survey-based) and objective indicators. The dimensions weigh equally but	• Developed for measuring well-being in Bhutan • Happiness is not measured only by subjective well-being, and not focused narrowly on happiness that begins and ends with oneself and

Index Name	Agency or Author(s)	Theoretical Framework	Indicators	Coverage	Data Source	Index Calculation	Indigenous consideration
						the indicators within each domain is unweighted • Alkire-Foster method • Three cut off 50% (unhappy), 66% (narrowly happy) and 77% (deeply happy)	is concerned for and with oneself
Canadian Well-being Index Launched in 2011, annual report	Atkinson Charitable Foundation University of Waterloo, Canada https://uwaterloo.ca/canadian-index-wellbeing/	• To encourages Canadian people to question the way decisions are currently made, and to consider alternative ways to promote a higher quality of life.	1. Community vitality ✓ Social relationships ✓ Social Norms and values 2. Democratic Engagement 3. Education 4. Environment 5. Healthy populations 6. Leisure and culture 7. Living standards 8. Time Use	1. Launched in 2011 2. Annual report 3. Only for Canada	Data sources based on Canadian social survey and other Canadian national agency, include: Statistic Canada Surveys, General Social Survey, Canadian Community Health Survey, Labour Force Survey, Canadian Survey of Giving Volunteering and Participating, Canadian Election Surveys, Environment Canada, WWF living Planet index, Canadian Centre for Economic Analysis	• Combining the scores for each domain, over time to monitor overall increases or decreases in the wellbeing • Human Well-being is defined as the presence of the highest possible quality of life in 8 dimensions (see Column 4)	Dimensions on the index are developed from expert advice and focus group Canadian people in several time series.

Index Name	Agency or Author(s)	Theoretical Framework	Indicators	Coverage	Data Source	Index Calculation	Indigenous consideration
Better Life Index (bi-annual report, since 2011)	OECD http://www.oecdbetterlifeindex.org/	• Stiglitz & Sen report (2010) • Measurement of Economic Performance and Social Progress • Sen's capability approach	Material Condition 1. Housing 2. Income 3. Job Quality of Life 4. Education 5. Health 6. Environment 7. Community 8. Civic engagement 9. Safety 10. Work life balance 11. Life satisfaction	1. Bi-annual since 2011 2. Cover 36 countries as of 2016 3. Cover 41 countries as of 2017	Data collected by OECD and from international organization, include European Union Statistics on Income and Living Conditions (EU-SILC), National Statistical Office, Gallup World Data on life evaluation	Equality-weighted arithmetic mean for aggregation for all 11 dimensions	Interactive website to allow each individual to compare national progress and his or her own progress
Social Progress Index	Social Progress imperative – USA https://www.socialprogressindex.com/	Social progress as the capacity of a society to meet the basic human needs of its citizens, establish the building blocks that allow citizens and communities to enhance and sustain the quality of their lives, and create the conditions for all individuals to reach their full potential	Basic Human Needs 1. Nutrition and basic medical care 2. Water and sanitation 3. Shelter 4. Personal Safety Foundations of Well-being 5. Access to Basic Knowledge 6. Access to Information and Communications 7. Health and Wellness 8. Environmental Quality Opportunity 9. Personal Rights 10. Personal freedom and Choice 11. Tolerance and Inclusion 12. Access to Advanced Education	1. Annually since 2013 2. Cover 128 countries as of 2017 3. Excluding the subjective well-being 4. Excluding economic indicator	Data from international and reputable organization, include: FAO, WHO, UN Inter-agency Group for Child Mortality Estimation, UNICEF Joint monitoring programme for water supply and sanitation, Gallup World Poll, Sustainability energy for all, World economic forum global competitiveness report, Institute for health metrics and evaluation, UN office on drugs and crime, Institute for Economics and Peace Global peace Index, WHO, UN educational scientific and Cultural organization institute for Statistics, International Telecommunications Union, Reporters without Borders, WHO, Institute for Health Metrics and Evaluation, Yale Center for Environmental Law & Policy and Columbia University Center for International Earth Science Information	• Average of three dimensions. For each dimension, average of the components. • SPI is from 1-100	• Exclusively only to include social and environmental indicators • Only include Indicators that are measured well, with consistent methodology, by the same organization, and across all (or essentially all) of the countries

Index Name	Agency or Author(s)	Theoretical Framework	Indicators	Coverage	Data Source	Index Calculation	Indigenous consideration
					Network Environmental Performance Index, World Resources Institute, Freedom House, World Justice Project Rule of Law Project, Heritage Foundation, Pew Research Center Government Restrictions Index, OECD Gender, Institutions and Development Database, UNDP, Transparency International, Fund for Peace Fragile States Index, Barro-Lee Educational Attainment Dataset, Times Higher Education World University Rankings, QS World University Rankings, and Academic Ranking of World Universities; SPI calculations, UNESCO		
Composite Global Well-Being Index	American University of Beirut, Beirut, Lebanon (Chaaban et al. 2016)	Well-being is including both the material and other aspects of an individual's quality of life	1. Safety and security 2. Health 3. Education 4. Housing 5. Environment and Living Space 6. Employment 7. Income 8. Life Satisfaction 9. Community and Social Life 10. Civic Engagement	• First report in 2016 • Cover 124 countries as of 2016	International databases such as: the International Labour Organization Key Indicators of the Labor Market database, UNPD, World Bank World Development Indicators (WDI), the Institute for Economics and Peace Global Peace Index (GPI), the World Health Organization Global Burden of Disease statistics (WHO-GBD), United Nations Office on Drugs and Crime (UNODC), the United Nations Relief and Works Agency for Palestine Refugees in the Near East (UNRWA), the United Nations High Commissioner for Refugees (UNHCR) Statistical Online Population Database, and Gallup World	• Unweighted arithmetic mean for aggregation for all 10 dimensions • A 5 year average was calculated for most flow indicators	Extension of OECD Better Life Index

Index Name	Agency or Author(s)	Theoretical Framework	Indicators	Coverage	Data Source	Index Calculation	Indigenous consideration
					Poll for life satisfaction (Chaaban, Irani & Khoury, 2016)		
Gross National Wellbeing	International Institute of Management, USA	• Inspired by Bhutan GNH philosophy, to create an index that balances economic development framework • Links government policies to life satisfaction	Measuring overall satisfaction in 7 dimensions: 1. Mental & Emotional Wellbeing 2. Physical & Health Wellbeing 3. Work & Income Wellbeing 4. Social Relations Wellbeing 5. Economic & Retirement Wellbeing 6. Political & Government Wellbeing 7. Living Environment Wellbeing	• Initiated in 2005 • USA only	Data is collected with online survey The survey also includes 4 four qualitative questions to identify key causes of happiness and unhappiness: 1. What are the top positive things in your life that make you happy? 2. What are the top challenges and causes of stress in your life? 3. What would you advise your government to increase your well-being and happiness? 4. What are the most influential city, state, federal or international projects? How are they impacting your well-being and happiness (positively or negatively)?	Equally-weighted of each dimensions	• Subjective survey only • Generic indicators, adaptable to other countries
Years of Good Life (YoGL)	IIASA www.iiasa.ac.at	• Brundtland Report on well-being function • Sen capabilities approach	• Being alive • Being out of poverty • Having no serious physical activity limitation • Being cognitively function • Being satisfied with life	• As many country as possible • Recurrent data collection	• Only reputable data that consists of individual data • Life expectancy from World Bank • Plan to collect own data	Persons years in the life table will be counting if the person is positive in all dimensions	Case study will be conducted in several countries to confirm the generality of the dimension and the needs for indigenous indicator

Conclusions and outlook

This paper introduces a new composite indicator of Years of Good Life (YoGL) which has been explicitly designed for the assessment of changes in overall quality of life over time as well as for the comparison of sub-population of human being. The conceptual framework that constitutes the basis of this composite indicator brings together three different concepts: The demographic concept of the life table, as being alive is an essential pre-requisite for enjoying any quality of life. But since mere survival is not being considered as sufficient this is combined with objective indicators of wellbeing following the capabilities approach and a subjective indicator based on the life satisfaction measurement approach. In the context of a distinct differentiation between indicators of means and of ends, YoGL has been designed to be an indicator of ultimate ends. In other words, it combines capable longevity with overall life satisfaction. These should be ultimate ends that are widely shared across all cultures and generations.

YoGL as a well-being indicator has several important properties that make it fit as an indicator to serve as a sustainable development criterion. Firstly, YoGL is grounded on observable individual characteristics that can be grouped into sub-populations which distinguishes YoGL from other indices that use only nationally observable data. YoGL is also meaningful with a real life analogy in its absolute value that can be estimated and based on certain models, even forecasts, for comparison not only across sub-populations but also over time. Finally, in terms of empirical estimation of YoGL, there are so far not many survey data that for the same individuals give reliable information for all the four dimensions of YoGL (subjective life satisfaction, being out of poverty, being not disabled and being cognitively able to read). The broadest survey data with all this information is in the set of SHARE surveys for female population aged 50 years and above for 17 countries. Another survey including all this data for women from age 20 onwards is from the Philippines. Both sets of survey data have been used in this paper to empirically illustrate the application of YoGL. The results also show how in different populations there are different reasons for the years of good life to be lower than total life expectancy.

The purpose of this paper was to present the theoretical reasoning for this new indicator, to illustrate how it can be calculated, and compare it to other existing indicators of human wellbeing. As a next step the information will be collected for many more populations and methodologies will be developed to impute data from surveys in which not all of the dimensions are simultaneously included. Then statistical models will be estimated to assess its determinants (well-being production function) on a broad empirical basis. This will be complemented by in-depth case studies for specific locations and populations. Also, quantitative systems models will be developed to assess and forecast under alternative scenarios the feed-backs from human induced and other environmental as well as socio-economic changes on the future trajectory of YoGL. We are aware of the highly ambitious character of this project, but are convinced that such an approach is necessary for comprehensively assessing the drivers of future human well-being of different sub-populations on our planet and how they can be influenced by policies.

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