ABC of sustainable development

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For my brother and friend, Ramprakash

Preface and Acknowledgements

Thanks to Prof Dr Giuseppe Genon of Politecnico Torino (Turin, Italy) and Dr Håvard Bergsdal, my good friend, who accepted my request to be reviewers instantly. Thanks to Prof Genon also for the Foreword to this book. Thanks to Prof Artur Pawlowski, Editor of *Problemy Ekorozwoju*, for permitting me to reuse one of my published papers from the said journal as one of the chapters in this book.

The success of this venture can be gauged only by, firstly the number of downloads over time, and how useful it turns out to be for the students reading it. If this book inspires fresh thought and most importantly, the conversion of such thought to purposeful action, that would be the greatest reward for this author.

I cannot thank my wife Varshita enough for standing by, encouraging and supporting me, as I started work on this book, as a person who had just lost his job after 8 years of concerted work at the Norwegian University of Science and Technology in Trondheim…sitting in a coffee shop in the city, from morning till evening. If this opportunity has come my way, by God's will, I would want the output to benefit as many students as possible, for as long as possible, for that surely would be God's wish and purpose behind sending this opportunity my way. Thanks to Karin Jakobsen of Bookboon for enabling this. Thanks to my mother for her prayers and blessings, to sustain me through the relatively-difficult phase in life.

I have avoided having a list of references at the end of this book and resorted to inserting endnotes in the chapters. Each chapter begins with *Learning Objectives* and a set of *Exercises* which the students are encouraged to attempt, *en route.* A Glossary has not been provided, and in most cases, the endnotes suffice.

This book is certainly very far from being the be-all and end-all of knowledge about sustainability and sustainable development, as readers will appreciate. I am sure what one would call 'a Bible of Sustainable Development' exists, and perhaps is being put to use by professors and students. This modest effort is something which I hope provides some food for thought…and then action.

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June 25, 2015

Foreword

In many different fields of human activity, the concept of sustainability must be carefully considered. In fact, many processes and operations, ranging from primary extraction of resources, to technological production of goods, to public services directed to the satisfaction of human needs, can have various negative impacts on the environment and society.

From the trade-off between the satisfaction of social/human needs and limiting environmental loads/burdens, the existence of a condition of sustainability can be determined, as a satisfactory point of fulfilment of different public and private needs.

This concept of sustainability, traditionally used in the field of environmental evaluation of limits for the exploitation of resources and technological activities in the context of the carrying capacities of the environmental media, must also be considered from the social point of view – on account of the interaction between industrialization and developments in manufacturing/production on the one hand, and a fair and reasonably-equitable distribution of the 'produced riches', and also from a human, cultural point of view, so that an acceptable level of quality of human life can be achieved.

These aspects have been dwelt on, by G Venkatesh, in this e-book which introduces the different aspects of sustainability. After presenting the structure and characteristics of a well-organised society and an integrated scheme of production/manufacturing, the author writes about the different aspects of sustainability with a clear indication of the meaningful parameters that one may be able to calculate/estimate with a concrete, numerical approach. The limitations and the need for continued thinking and refinement of the approach have also been stressed upon.

The experience of the author in the field of 'definition of acceptable use of resources' and 'optimal management of public services' is usefully enlarged and integrated with social, political and planning considerations for sustainability, in order to establish a more general set of criteria of acceptance for all the activities of an organized society in a postmodern world.

After the presentation of the theoretical structure of the sustainability evaluation assessment, some specific examples referred to particular situations are introduced, in order to illustrate the proposed approach and elucidate understanding.

The introduced focus on sustainability, transversal and inter-disciplinary among different specific engineering, economic and social competences, can be a useful methodological support to the necessary policy considerations that must be made, for a mature assessment of technologies and economies of the developed and developing world. This is also useful to university curricula, aimed at grooming professionals capable of considering all the aspects of sustainable development and of course, can very well be integrated into a host of academic disciplines, as the author has pointed out in one of the chapters.

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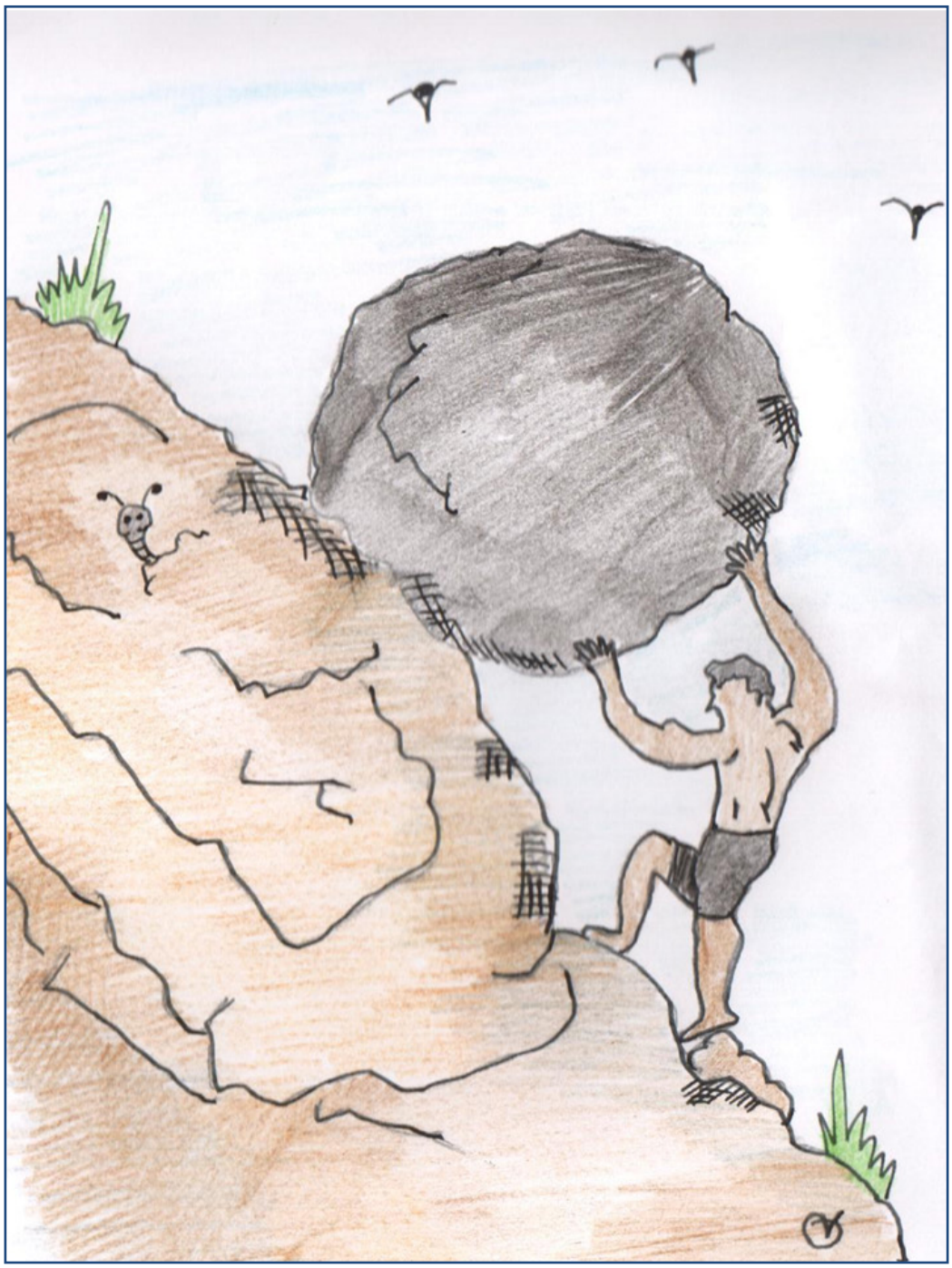
'We have favoured self-assertion over integration, rational knowledge over intuitive wisdom, science over religion, competition over cooperation and expansion over conservation. This one-sided development has reached a highly-alarming stage; a crisis of social, ecological, moral and spiritual dimensions.'

Fritjof Capra, in the Preface to the second edition of the book '**The Tao of Physics**', written in 1982.

1 The beginning…

Learning objectives: This chapter is a breezy-read and the intention is to help you, the reader, to essentially understand the import of the terms 'sustainability' and 'sustainable development' and also to open the doors to the chapters that follow this one…Just read as if you are reading a magazine article!



There are words, terms and phrases one hears often on television and radio, in conferences and casual conversations, and reads in newspapers and magazines. The mind conjures its own meanings. All minds do not necessarily agree with one another. These 'conjured meanings' then dictate the extent to which something is understood, supported, contradicted, or for that matter, simply ignored as irrelevant. The word 'sustainability' and the term 'sustainable development' are two such.

The former has its etymology in the Latin word *'sustinae'* meaning 'to hold', which this author's mind or readers' minds could conjure as 'to endure', 'to maintain' etc. The word 'development' originates from the French word *'développer'*, which means 'to unfold'. Thus, when we say 'sustainability', we are talking about the ability to endure or maintain, and by 'sustainable development', we imply 'moving ahead while making sure that we can maintain, manage and do justice to the changes we seek and intend to bring about'. Now, let us clearly differentiate between these two terms. Oftentimes, they are erroneously used as synonyms. It is thereby imperative that the reader always remembers the difference between these two.

Sustainability refers to a state, or an ability. Sustainable development is a process. This process is essentially the means towards the end, which is sustainability itself. Here, it is necessary that the means – the process of development and all that it entails – are sustainable, in order to justify the end. As the lead picture of the chapter depicts, sustainable development is no less than a Sisyphean struggle[2]. And one can well remember this limerick[3], when one tries to visualise sustainable development – *'Rob Peter to pay Paul; Pay Peter by robbing his son; Plug a leak at Vauxhall; End up flooding Wimbledon'*. Also note that the end here – the state of sustainability – is itself a moving target. One needs to restlessly endeavour to keep pursuing it and try to minimize one's distance from it, through the means of sustainable development. The bar is raised from time to time, necessitating a fresh analysis and evaluation of the process, and an adjustment thereof, before the next pursuit begins.[4] As said in Kallio, et al (2007)[5], the phenomenon we label as sustainable development can never be exhaustively defined; it would constantly change with time, interpreters and their needs. We thus have an elusive, impermanent end-goal, which is pursued with a changeable set of ways and means. Quental, et al (2011)[6] has stated that the introduction of sustainable development as a concept was an intellectual answer to reconcile the conflicting goals of environmental protection and economic growth.

In Hindu philosophy, a thing is understood by understanding what it is not in the first place. Let us adopt that approach here. What is the absence of sustainability (or for that matter, sustainable development)? Let us just take commonplace, mundane examples which all of us are familiar with. It is like having many children without being sure of being able to care and provide for them in the future. It is like enrolling for a course in the university, without really being sure of one's ability to do the necessary hard work in fulfilling all the requirements – assignments, projects, examinations etc. – to get a decent grade in the end. Little things, these, on familial and individual levels; but it is the decisions taken at these levels, collectively, which influence those at county, provincial and national levels at times. This is what one may term as a bottom-up approach to change and development. In a way, this throws the balls, so to say, into the courts of individuals and families, as far as the larger cause – sustainability – and the necessary means – sustainable development – are concerned. Not avoiding individual (or citizen) responsibilities will just make it a wee bit easier for all of us to adopt the desired 'means' towards the desired 'end'.

1.1 Space, time and just about everything

When we talk of sustainability, as it is a moving target, the process of sustainable development needs to keep going on. It is never completed! Thus, the temporal aspect here suggests that while long-term thinking needs to be adopted, the process never really stops. It is quite like a never-ending relay race, with the baton changing hands, and the demands fluctuating, with 'sustainability' being the constantly-receding goal which a team of countless athletes, keep pursuing in turn.

As far as the spatial aspect is concerned, we are all connected, through the atmosphere, hydrosphere and pedosphere, and the anthropospheric constructs of trade and travel. What I do now, may/can/will impact someone else somewhere adversely or favourably. If space and time are considered together, this someone else somewhere, may even be a person who is not even born at the time of the deed. This is an apt-enough juncture to recollect a statement from the (Gro Harlem) Brundtland Commission Report[7] – *Sustainable development seeks to meet the needs and aspirations of the present without compromising the ability to meet those of the future*. In other words, is it possible to ensure that someone somewhere at some point of time in the future is not adversely affected by what I do here now? Tempted to just say 'No' and give up the pursuit of sustainability? Of course none will blame you if you did, but surely if you decide not to give up, you may end up being the change you wish to see in the world.

One man's food is often another's poison. A job acquired by someone here is tantamount to a job or more lost elsewhere (Consider a manufactory relocating to China from the USA; retrenching the American workforce and hiring cheaper labourers in China). More trees cut down in the Scandinavian forests may mean more 'moolah' for paper and pulp mills elsewhere, and perhaps employment generation. A school built on a plot of land could mean one hospital less for a city. Some people may contend that the plot of land on which a 1000-year-old church stands could have been put to better use if there had been an automotive-components manufactory there, to generate employment and boost the economy of the city. Some others would like to opine that the old church is not just a necessity for the believers in town, but also a magnet which attracts tourists off and on, and contributes to economic growth in its own special way. What is the right thing to do then, when one wishes to change, develop and progress? (Refer Figure 1-1, which illustrates the challenges planners face if total sustainability is factored into decision-making). The three Ps in the Figure – People, Planet and Profit – define the triple bottom-line approach, first introduced by John Elkington.[8]

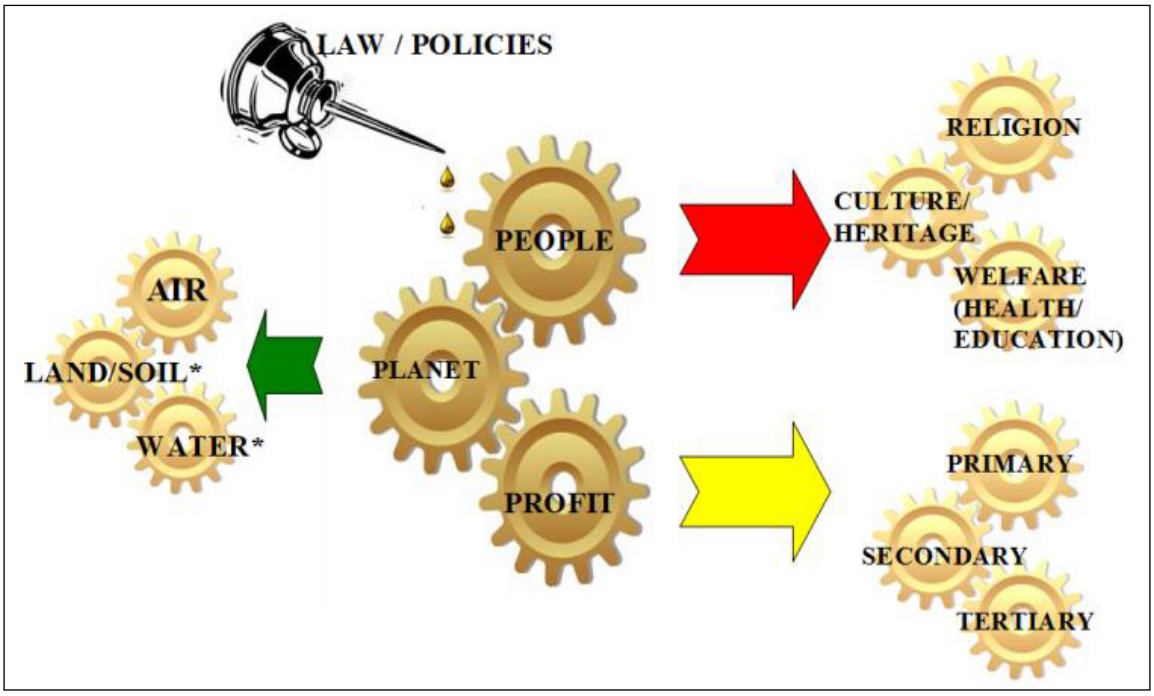


Figure 1-1: The wheels-within-wheels nature of sustainable development[9]

Can one ensure that the economy does not take a severe beating, the environment is not allowed to run to seed, the unemployment rate is brought down and controlled, more and more children get to go to school and stay healthy, and our heritage is conserved for its non-monetary value, all at the same time? Is this even possible? Does any course at university teach you how to accomplish this? Or, are you left confused with a string of diverse subjects, often contradicting each other – Economics, Environmental Engineering, Sociology, Philosophy etc.? Are you on the lookout for a subject or module which will help you to think in terms of integrating seemingly-conflicting disciplines and adopt a holistic, balanced and 'sustainable' approach to life, learning, decision-making and planning; and enable you to leave the world a more sustainable place than what it was when you were born?

This book will hopefully serve as a primer. It does not purport to answer all your questions, let alone tell you how to make perfect decisions. 'Perfect decision' is very much a misnomer! However, while not being able to answer all your questions, it surely will make you question, criticize, challenge, learn, unlearn and relearn, and put you *en route* to pursuing the elusive 'total sustainability' – the path which can also be called '(total) sustainable development'. The journey is more enjoyable than the destination, as they say. In this case though, there is no destination *per se*, where you can bask in the Sun for long. You would need to pull up your socks and get going…on the never-ending journey towards sustainability. (Note that one could talk of just social sustainability, economic sustainability or environmental sustainability, or total, holistic sustainability where all these aspects are factored in. Hereafter, if only the word 'sustainability' or the term 'sustainable development' is used, the reference is to 'total sustainability' and 'holistically-sustainable development')

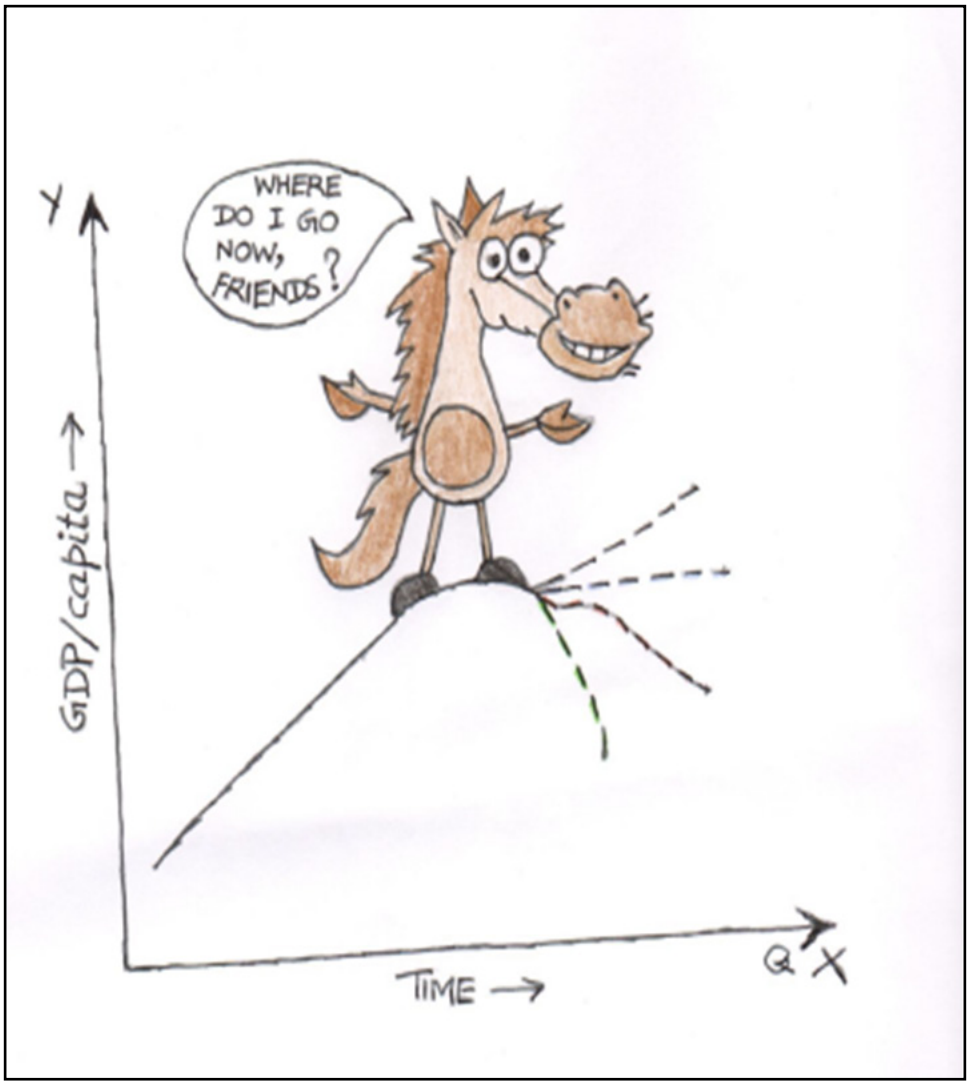
I hope that this book will well and truly motivate you to think seriously about 'sustainability' and 'sustainable development'. Before you move on to the next chapter, it would be a good idea to have a go at the Exercises below. You can thereby 'sustain' yourself while reading the other chapters…

1.2 Exercise I

1. If someone said that the pursuit of a goal you know you will never reach is futile, and so should never be attempted – the goal being sustainability here – how would you respond?
2. How does one decide in the first place if the status quo is sustainable or not? Discuss this in the context of the truth that sustainability is a moving target.
3. If you have majored in environmental engineering, how easy or difficult would it be to factor in other aspects of sustainable development – economic, socio-cultural, etc.?
4. Can you think of something in your daily life which you may want to do differently and more 'sustainably'? Discuss.

2 The economic aspect – Money makes the mare go round

Learning objectives: This chapter intends to introduce the reader to the terms 'economic growth' and 'economic development' and point out the nuances which differentiate one from the other. The reader will understand the conflict between attempting to pursue only economic sustainability on the one hand, and socio-economic sustainability on the other. He/she will also be introduced to the concept of economic feasibility and the tool, life-cycle costing (LCC, which is used as a decision-making tool by enterprises and firms embarking on new projects), and realise that LCC on a firm level, aids the progress towards economic sustainability eventually on an economy-wide scale.



A surplus of money does not guarantee happiness, agreed. But lack of it surely does not make one happy. While firms seek profits (one of the 3 Ps in Figure 1-1), the employees they hire, work for their livelihoods, and this work results in economic outputs (of which profits are a part). Money earned (through the sale of products and services) by enterprises is then used to pay wages and salaries to employees, pay taxes, repay loans with interest, and invest in further growth if possible. The global marketplace stimulates imports and exports, creating the 'anthropospheric construct of trade' referred to in Chapter I. How well an economy is performing in absolute terms, is generally gauged from the indicator – Gross Domestic Product (GDP). There are some who believe that the indicator 'GDP/capita' is a much better one. But we know for sure, that GDP-per-capita is also misleading. One needs the Gini Index[10] in addition, also to decipher if Pareto's 80:20 theory[11] is more or less applicable to income distribution among the population. (Note that Corrado Gini was a sociologist; and Vilfredo Pareto an economist, and thus when we consider GDP/capita and Gini Index together we are dealing with the 'socio-economic' aspect in sooth.) Once again, we can differentiate between just economic 'growth' (which is just an augmentation of the GDP or the GDP/capita) and economic 'development' (which would imply a reduction in the Gini Index progressively towards zero, and diversification, about which we shall discuss in the next section of this chapter.) One could define 'economic sustainability' (as opposed to total or holistic sustainability) as simply sustaining economic growth – that is, focusing on GDP growth (or for that matter, increase in the value of the indicator 'GDP/capita'). When we talk of economic development, as referred to above, we move into the socio-economic realm – and merge economic sustainability with an aspect of social sustainability (sustaining an as-low-as-possible Gini Index). This means that we can define economic development as the process or path towards an aspect of the elusive socio-economic sustainability; just as sustainable development is the process undertaken to pursue the elusive goal of total sustainability.

2.1 Trifurcating the economy

When we talk of economic growth or economic development, we need to understand the structure of the economy of a country or region first. As Figure 1-1 depicts, the economy is usually trifurcated into the primary sector, secondary sector and tertiary sector. The primary sector which includes activities like mining, lumbering, fishing and agriculture, can be looked upon as the supplier of raw materials to the secondary sector (manufactories) which receives them and processes them before selling to end-consumers. The tertiary sector is not as resource-heavy as the secondary or the primary, and is usually associated with the use of knowledge and time (as resources) to produce services. These are intangible goods, so to say, and include attention (heath-care for instance), advice (legal services and consulting for instance), access (telecommunications etc.), entertainment (media), *inter alia*.

Sector / *Sub-sector*	Contribution in %, in year, Y	Contribution in %, in year, Y+1
Primary	A	A_1
Mining	A-a	A_1-a
Agriculture	A-b	A_1-b
Fishing	A-c	A_1-c
Secondary	B	B_1
Food processing	B-a	B_1-a
Metallurgical industry	B-b	B_1-b
Pharmaceutical industry	B-c	B_1-c
Paper and pulp mills	B-d	B_1-d
Other manufactories	B-e	B_1-e
Tertiary	C	C_1
Media (print and audio-visual)	C-a	C_1-a
Banking and insurance	C-b	C_1-b
Hospitality, entertainment and recreation	C-c	C_1-c
Legal services	C-d	C_1-d
Transport/Mobility	C-e	C_1-e
Healthcare	C-f	C_1-f
Education and research	C-g	C_1-g

Table 2-1: Trifurcating the economy of a hypothetical country, and sub-dividing its sectors further

The growth of each of these sectors necessitates the presence/promotion of conditions which are conducive. For instance, all countries are not blessed with mineable resources. Landlocked countries do not have the potential to promote a fishing industry. Different soil types and rainfall patterns would mean different forms of agriculture and thereby different types of farm outputs. Absence of forests would mean the absence of a lumbering industry. As far as the secondary sector is concerned, access to manufacturing and processing technologies, support from the government, access to cheap (not necessarily always though) labour, encouragement provided to entrepreneurs, access to capital, and the presence of a ready market within the country and/or export possibilities are all necessary (though perhaps not sufficient) factors for growth. The tertiary sector calls for a different level of expertise and thrives on the availability of a well-educated (or creative and talented, for the entertainment sub-sector) workforce.

It is thus possible to trifurcate the economy and then further identify a range of sub-sectors under each of the three categories and study the existence/absence of and opportunities for/hurdles to growth, for different provinces within a country, or different countries within a region (See Table 2-1). Note that the sub-division here is arbitrary and this is not necessarily the way it may be done.

It goes without saying that in Table 2-1, A+B+C = A_1+B_1+C_1 = 100%; A-a, A-b and A-c add up to A, and so on for B, C, A_1, B_1 and C_1. If the economic output in years Y and Y+1 can be measured in GDP, then economic growth would simply mean that the GDP in year 'Y+1' is greater than that in year Y. Even if the absolute value of GDP increases from year-to-year, in case the rate of increase of the population is greater than that of the GDP itself, then, the value of the indicator – GDP/capita – will decrease in year Y+1, with respect to year Y. Now, does this connote economic growth or an economic downslide? It all depends on which indicator one wishes to use to measure economic growth!

Let us adopt GDP/capita and consider that the value in year Y+1 is greater than that in Y, and that economic growth has thereby been registered. It is likely that the contributions of each of the sectors and sub-sectors remain the same in both years. But the probability of this happening is actually very low. A host of supportive factors may result in one sector (or some sub-sectors) registering much higher growth than the others; and thereby account for a much greater share of the pie in year 'Y+1'. It is also possible that the contributions of some sub-sectors decrease in absolute terms. With economic growth, economic sustainability is however attained, but with the degree of diversification dropping, is economic development or the march towards socio-economic sustainability safe? Perhaps not. Sub-sectors which have not done well may perhaps be hard-pressed to retrench a part of their workforce. It may also not be possible for the booming sectors / sub-sectors to absorb this retrenched workforce, owing to a mismatch of skillsets and capabilities. The 'employment generation' or 'employee retention' component of socio-economic sustainability thus suffers.

If economic growth is the only point on a government's agenda – which would be utter naïveté – it will just focus on those sectors and sub-sectors which are booming and neglect the others. It may assume that the citizens who end up unemployed, underemployed or underpaid/unpaid, may somehow fend for themselves and adapt and cope. A jump in absolute GDP will more often than not, also increase the tax receipts for the government (the booming sectors chipping in with the lion's share of these); and the handing-out of unemployment allowances may be looked upon as a stopgap. These allowances would effectively be given out to the unemployed, in return for no positive contributions to the economy, apart from the subsequent expenditures on food, rent, etc. This evidently cannot go on, *ad infintium*. This is an unsustainable situation, socio-economically, right from the outset. Economically, as long as the sectors which are doing well, keep doing well, and people who are on the dole keep getting their allowances which they then spend again, with what is given to them being recirculated again into the economy, this may be sustained.

The discussion so far was about decision-making on a national/provincial/municipal level. But when an enterprise/firm has to make a selection from among many alternatives, it would use 'economic feasibility' as a guiding criterion (or ideally one of the guiding criteria, as we shall see later in a subsequent chapter). Before understanding the link between economic feasibility for a firm and economic sustainability for a city/province/country, we can throw light on how firms go about deciding which of the alternatives they have, is economically the most feasible.

2.2 Life-cycle costing

The LCC methodology[12], is adopted by firms and enterprises when a choice has to be made among a series of alternatives (for change), to establish economic feasibility – in other words, the potential to maximize benefits over the life-cycle. (Note that in the cited reference, the application of the LCC is specifically to buildings.) Referred to variously as whole-life costing analysis, womb-to-tomb costing analysis, or cradle-to-grave costing analysis, LCC can very simply be defined as the total cost of ownership over the lifetime of an asset (plant or equipment for instance), which is providing benefits of some kind. Expenditure and income streams of the future are expressed in terms of their present value, by considering discount rates, and subsequently the net present value (NPV; the difference between the total present value of all income streams and the total present value of all expenditure streams) is calculated. As shown in Figure 2-1, the income and expenditure streams in real 'year-0' currency units (adjusted for an expected interest (discount) rate, with respect to year '0') are identified for every year of the life-cycle. The discount rate, as indicated, is r %, and year '0' in which the capital investments to construct the system are made, is considered as the year to which all the incomes and expenditures are to be discounted back, to determine the NPV. If C_n stands for the costs or expenditures in year 'n' and B_n stands for the income or benefits in year 'n', then the NPV is calculated as below in Table 2-1 (assuming in this instance, a nine-year lifetime, and no operation in the year labelled '0', during which only capital investments occur).

$$NPV = -C_0 + \sum_{n=0}^{9} (B_n - C_n)/(\mathbf{1} + \mathbf{0.01} * \boldsymbol{r})\text{^}\boldsymbol{n} \qquad \textbf{(Equation 2-1)}$$

The firm would select the alternative which has the highest NPV value. The purpose of performing an LCC would thus be to determine the most profitable investment- expenditure alternative available.

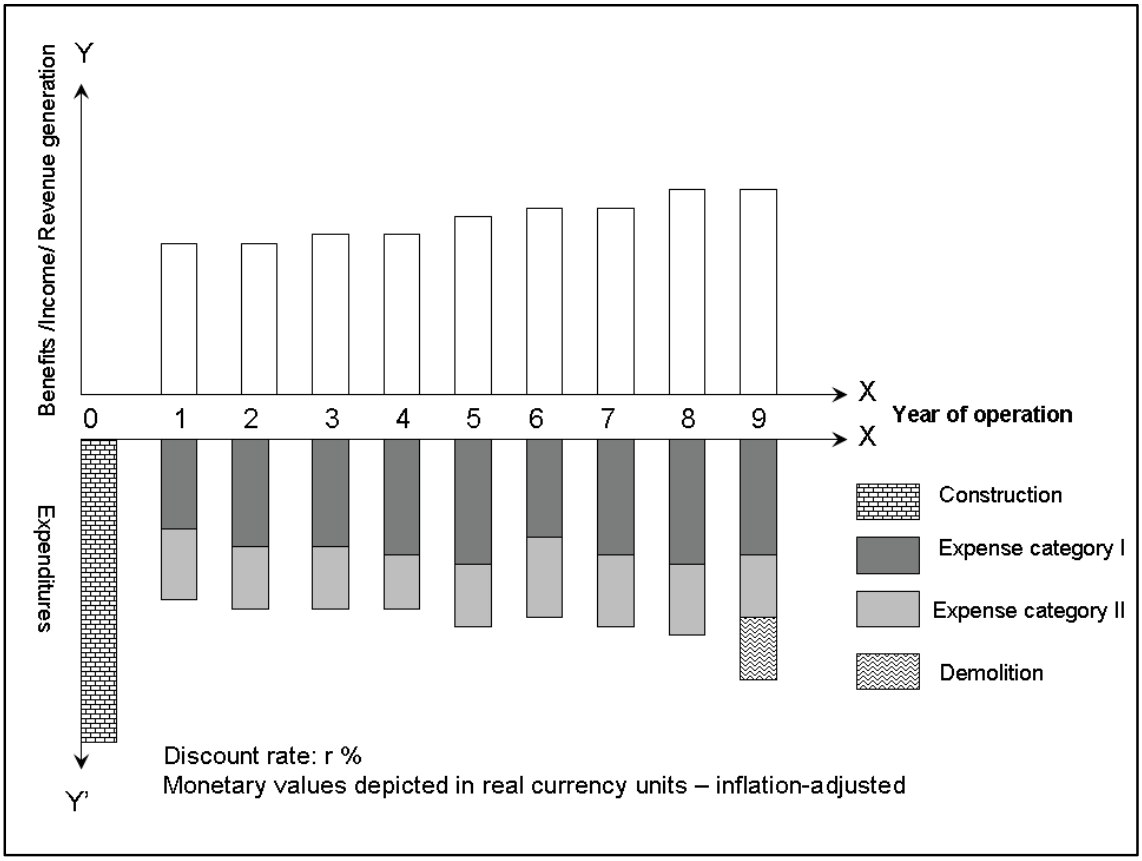


Figure 2-1: Life-cycle costing[13]

2.3 Good for goose, good for gander

Thus, the NPV will be a useful indicator for a firm which targets economic feasibility. Now, how would profit for an individual firm (whereby its net benefits are greater than the net payments it makes to the economy external to it) benefit economic growth (or economic sustainability)? Well, money circulates within the economy after all. A firm may charge more for its services and products from its clients, but would then somehow channel back the profits into the economy. Taxes would have to be paid on the profits the greater the profits made, the greater the tax receipts for the local/provincial/national government/s if one assumes that businesses do not resort to tax evasion). Bonuses and salary increments provided to employees would mean that they would spend more on food, clothing, entertainment etc. Investments made in brownfield expansions would mean an uptick in the production, and a slight rise in employment generation. If a firm which has not been exporting, decides on the basis of its profits to spend on diversifying into the global marketplace, it contributes to the country's export earnings.

Thus, aiming for greater economic feasibility ultimately results in greater economic sustainability (or rather socio-economic sustainability; if the firm uses its profits to diversify its product/service range, and provide employment to more people). A point to be noted here is that a firm by extending its geographical footprint (by setting up shop in a country other than where it is originally based), can play a key role in the socio-economic sustainability of the host country, by creating jobs and good working conditions and paying fair wages.

A planner at a municipal, provincial or national level, would set GDP or GDP/capita targets while pursuing economic sustainability. If the approach he/she wishes to adopt is a little more holistic, he/she would like to add targets for the Gini Index and the total employment rate (which would ideally be '100% – Unemployment rate', if underemployment can be ignored), and also attempt to set individual targets for the sectors, and if possible, sub-sectors. As explained earlier, giving step-motherly treatment to some sectors/sub-sectors and being biased towards the cash-cows, is not really sustainable at all. Governments of oil-rich nations have been making this mistake, without perhaps realizing it (or maybe, they are aware of it, but are adopting an ostrich-like[14] approach to the situation, expecting the problem to go away by itself). One could thus think of a set of indicators like the ones shown in Table 2-2.

Total GDP per-capita, Gini Index, Total employment rate		
Primary sector's GDP per capita	Secondary sector's GDP per capita	Tertiary sector's GDP per capita
Agricultural GDP per capita	*Manufacturing GDP per capita*	*Hospitality sector's GDP per capita*
Mining GDP per capita	*Food-processing GDP per capita*	*Transport sector's GDP per capita*

Table 2-2: Expanding the range of economic indicators to include the socio-economic ones as well

Now, obviously, an increase in the values of most of these indicators is desirable, while the Gini Index needs to be decreased over time, from the point of view of socio-economic sustainability. Having set targets, the planner needs to think of ways and means to reach them. That would mean working very closely with the stakeholders, and understanding things as they are in reality. Sustaining or increasing the GDP per capita values for all the sectors and sub-sectors for which the targets have been set (as in Table 2-2), without damaging the socio-economic sustainability in any way, is a tightrope walk. For instance, one often hears of reductions in employee strength (pink-slips being handed out), just to stay afloat and profit by reducing the salary/wage component of corporate expenses. Favourable and progressive government policies, cleverly chalked-out subsidy schemes and tax rebate plans (which would not affect tax receipts adversely for too long), can ensure that economic growth does not end up being the 'end-all and be-all' of planning. Of course, at times, sacrifices are called for, by the citizens of a country who need to understand that the country is actually a collective of responsible individuals, and sacrifices are often demanded (silently or explicitly) from them, when the ship needs to stay afloat and endure the rough seas for a while. Here is where, one would expect sacrifices on the part of one and all – in direct proportion to their degrees of affluence. Thus we see, that the pursuit of socio-economic sustainability is not just the 'politicians' and bureaucrats' headache' but a responsibility that needs to be shouldered by one and all, the *hoi polloi*, for the sake of the common good.

One question which may crop up in the minds of readers is the relative importance of reaching all the targets set. After all, it would not be possible ever to be able to fulfil all the expectations laid out. This is where the concept of weighting comes in. It will be discussed in a subsequent chapter.

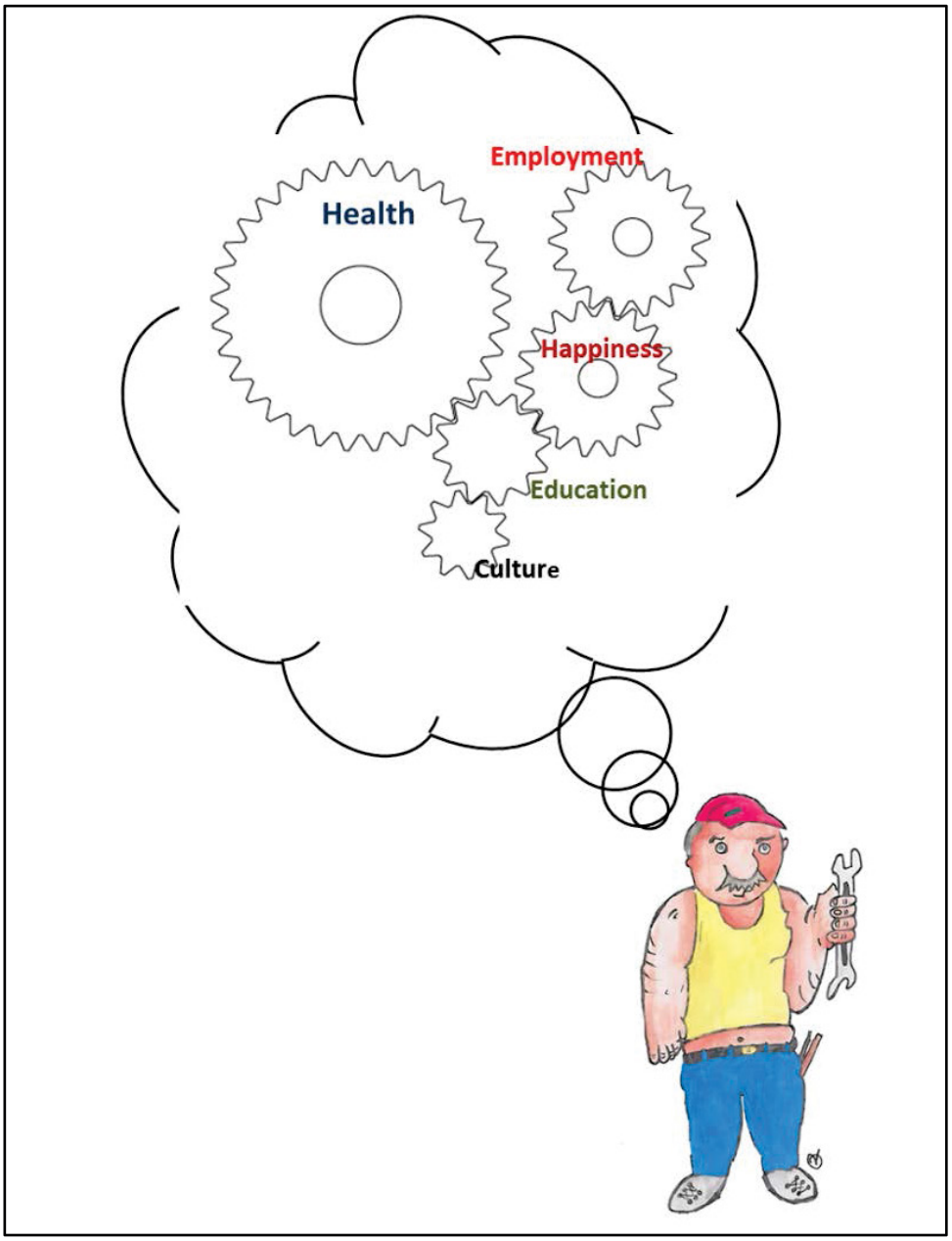
2.4 Exercise II

1. Choose any country you want to work with. Then, look for data akin to Table 2.1 for this country for two successive years. The Internet may have useful data somewhere, and you would seek to find them. Comment on how the sectors and sub-sectors have performed in the country. Also get data on how the unemployment rate has changed year-to-year. Discuss.
2. Countries in Africa have been registering stupendous economic growth in the recent past. Look for data on the Internet to identify some such countries. Yet, nothing much seems to change for them as regards total sustainability. Comment.
3. If you have majored in economics, would you be biased towards the economic indicators while measuring total sustainability? Would you do this for all countries at all points in time?

4. The author has defined and differentiated between the terms 'economic growth' and 'economic development' in this chapter. Further, the latter term has been defined as the process which takes one towards socio-economic sustainability. Do you agree? If not, provide your counter-arguments.
5. From the point of view of an LCC analysis, discuss the difference between a very high capital cost, and lower maintenance expenses, and a lower capital cost and perhaps higher maintenance expenses later on. How certain can one be about the maintenance expenses that would be incurred (considering that labour costs may fluctuate and costs of replacement parts for instance may also change appreciably in the future and obsolescence of technology will also have to be factored in)?
6. Try to think and understand the concept of weighting which has been introduced in the last paragraph before you actually read more about it in a subsequent chapter.

3 The social aspect – People first?

Learning objectives: This chapter intends to introduce the reader to the complex aspect of social sustainability and everything that it entails. The reader will at once learn to appreciate that sociology and psychology are as important as economics and 'financial engineering' if a meaningful progress towards total sustainability is to be made. The reader will also hopefully be motivated to learn more about Social-Life-Cycle Analysis (S-LCA). The exercises towards the end of the chapter will sharpen the learnings from it.



An economy, ideally, functions for the welfare of the people who comprise it – as producers and consumers. A healthy, happy, well-trained/well-educated populace, engaged in economic activity (in the three sectors), is very vital for economic sustainability. While the former is necessary for the latter, the latter ought to facilitate the former. There is surely a nexus between social sustainability (depicted in the lead picture of this chapter), as including health, education, culture/heritage/religion, employment which is a socio-economic component, and the more abstract and undefinable 'happiness') and economic sustainability, but an over-emphasis on one of these does not guarantee the other. Just as these two could complement each other if one focuses on ensuring such reinforcement, there could be conflicts as well, if one of the two is prioritised consistently over the other.

Imagine a case where you run very fast. You are able to maximize your displacement in a given period of time while running at a given velocity, if you run in a straight line. However, if you run for the same period of time, at the same velocity, around a circular path, the displacement is always less than the distance covered. While the distance keeps increasing as you keep going round, the displacement does not ever exceed the diameter of the circular path. **Just assume for a moment that the distance is economic sustainability and the displacement is social sustainability**. Running around in a circle imposes limits on the latter. Running straight ensures that the nexus is favourable for both. This is just an analogy which has been illustrated in Figure 3-1. Note that this is for the case of running round along a circular path (diameter considered to be 20 units in this instance). For the straight path, you would get a straight line making an angle of 45° with either axis, both having the same scale. You certainly would not wish to have social sustainability fluctuating in the manner shown, with economic sustainability (or economic growth in other words) increasing steadily.

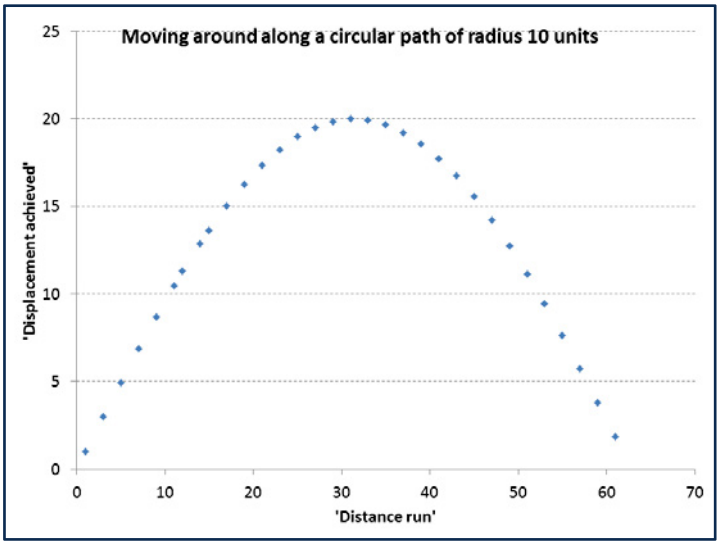


Figure 3-1: The analogy – Economic versus social sustainability

3.1 Health is wealth?

Burning the candle at both ends and working hard is unsustainable, simply because such behaviour will take a toll on your health after some time. The efforts will possibly get one economic gains as long as they last, but then, when health takes a beating, the efforts cease and the gains are then channeled back into healthcare. Wouldn't it be wiser to strike a balance, so that efforts do not cease and one does not overexert oneself? Well, this is something which individuals need to think about. Hankering after material gains at the expense of one's good health is quite like pursuing economic sustainability at the expense of all else.

Economic growth adds to government exchequers. Governments then have the prerogative to allocate funds to healthcare. Well-functioning, state-of-the-art public hospitals providing affordable healthcare, are employment generators themselves, even as they need to shoulder the all-important social responsibility of sustaining the health of the populace. Government initiatives apart, there often are enterprises in the private sector which cater to the mental, physical and holistic health needs of the population, while being essential components of the tertiary sector of the economy.

It must be remembered here that good health is not something which can be taken for granted. Individuals need to dedicate time, money and resources to ensure that it is sustained. Dedicating money to it, means enabling growth in the tertiary sector, and benefiting in return. Healthy people will be able to work efficiently (without the need to apply for sick-leave). Firms and enterprises, as part of their corporate social responsibility (which helps them in image-building), often invest in healthcare projects. They also take initiatives to enable their employees to stay healthy – providing gym memberships, opportunities to attend yoga classes, facilitating on-campus medical checkups, etc. Channeling some resources into healthcare, usually produces much greater benefits to the one doing so – individual, enterprise or government. (Here, as you may already have started wondering, a strong link to environmental sustainability also exists, as health is influenced greatly by the state of the external environment – water bodies, atmosphere, soil etc.)

However, a tricky, unsustainable situation may arise if the rate of increase in the working-age population is less than that of the aged. Japan and many countries in Europe are experiencing this. It is possible (though not always true) that sustaining economic growth may then become a wee bit difficult, and with it, sustaining affordable heathcare as well.

Public health is a complex subject and one can think of several indicators to describe it. There may not be one standard way to measure it as a component of social sustainability. Child mortality rate for instance is a good indicator but does not apply to the entire population. The average life expectancy (males and females) may also be another suitable one, but it is here that one may be confronted with the tricky situation referred to above. A seemingly desirable trend in this regard, may turn out to be an unmanageable one in the near future. The focus here though is on the word 'may'. With this understanding though, one may opt for these two indicators to encompass the entire population. A decrease in child mortality and an increase in life expectancy would augur well for social sustainability.

Figure 3-2: Product innovation by the corporate sector to safeguard health and help combat environmental hurdles (in this case, water-related)[15]

3.2 Education is an investment

You would certainly agree with this. This is true both for individuals as well as for cities and countries. Money spent by parents (on books, fees etc.) to educate their children is an investment, which enables the latter to sustain their livelihoods in the future. By expending on healthcare and availing of the healthcare facilities provided by the government and the private sector for themselves and their children, and also 'investing' in their children's education (this investment is, in sooth, an expenditure, which may pay dividends for the children in the longer-term), responsible adults would contribute to social sustainability. Enterprises/firms, as part of their corporate social responsibility initiatives may channel a portion of the allocated funds to setting up schools in villages, for instance, or providing scholarships to needy and deserving students for higher education.

But as with health, so also with education…there is no free lunch. Both firms and governments need to ensure that economic growth continues so that investments in health and education of the populace become possible. Governments need to focus on education, while not neglecting health, and vice versa. Tax receipts have to be deftly allocated; there is no hard and fast rule on how this is to be done. This is where decision-makers need to show a great deal of sagacity and foresight, and also be willing to learn from hindsight all the time. After all, sustainable development is a non-ending pursuit towards an elusive goal. It pays thereby to know where one has come from, in order to make the progress towards the elusive goal smoother and steadier and surer (Never forget that the progress towards the elusive goal does not mean attainment of the goal; it just means following close on its heels). Governments may decide to set up new schools where they are needed the most, subsidize education wherever and whenever possible, provide scholarships (like firms and enterprises may also do), to needy and deserving students, pay teachers in schools well in order to keep them motivated to continue in their noble profession, sponsor healthy lunches for students, *inter alia.*

However, sustainability of education is not measured or determined by the investments (or expenses) made by governments, individuals and firms, but rather by the outcomes or the effects of such investments/expenditures. There often are instances where money goes down the drain, when it is spent without conditions being imposed. And if this continues, it could then end up becoming truly unsustainable. One may then start feeling that the money could have been put to much better use elsewhere (health, culture, environment etc.).

Talking of outcomes or effects, how are these to be measured? Number or percentage of students passing out of school, number/percentage graduating from university, number/percentage securing PhDs, or simply number of people who learn to read and write (at least the local language), irrespective of whether they go to school or learn to do so in their spare time? If people learn to read and write in their spare time and do not attend school or university, no investments of money are called for. It would just be an investment of time; perhaps a volunteer (social-worker) may undertake the noble task of teaching the children of poor parents or adults who have never been to school, gratis. There are many who have been doing so…some are written about and some just work in the background. Economic growth may really not be necessary if the literacy rate can be raised in this fashion. But then raising the rate in this fashion may benefit economic growth in the medium-term. However, a thought may linger in the minds of readers – Does a well-diversified economy (all three sectors) really require a very high level of literacy? As people get more and more literate, will not they be dissatisfied with their jobs and start seeking opportunities to move up the ladder? Does not a sound economy need a sufficiently-diverse workforce? Difficult question to answer? Yes and no. You cannot force someone, in a democracy, to be content with where he/she is employed, and continue doing what he/she is doing throughout his/her life, for the supposed good of the economy and society. One also cannot shy away from widening opportunities for education and justify this stance by claiming that one wishes to aid the diversification referred to. Hence, we somehow come to the conclusion that just an increase in the literacy rate should not be the main focus, as it may really not benefit economic growth. 'Education' needs to be interpreted differently here – imparting different skills and different types of knowledge to different people to enable them to sustain their livelihoods and also contribute to economic growth in the process.

Hence, while child mortality rate or life expectancy may after all be useful indicators to measure 'health-related sustainability', deciding upon meaningful indicators to measure 'education-related sustainability' may be tricky. What do you, as a reader think, could serve as a meaningful indicator in this respect?

3.3 Cannot please God and Mammon both?

"No one can serve two masters. Either you will hate the one and love the other, or you will be devoted to the one and despise the other. You cannot serve both God and money."[16] This simply goes to show that if there is an inordinate focus on economic growth, making more money and enjoying the material gains of hard work, one tends to automatically and unavoidably neglect cultural and traditional values, national heritage, spirituality and God. While preserving such values and conserving heritage may call for investments (which would have to be sourced from the economic growth which cannot be overlooked *per se*), economic growth must not in any way necessitate the disappearance of religion and spirituality altogether. Here, the author is not advocating a fanatical pursuit of religion (this has become the bane of civilisation, for that matter), but perfect secularism, respect and tolerance.

A sizable chunk of the human race, at any time in history, has sought/seeks solace in churches, temples, mosques and synagogues – places of worship in general. Traditional forms of art and music, attire and food-habits, provide a great sense of contentment to many of us. Such contentment and satisfaction which is more on the mental, psychological and ultimately spiritual level cannot be sought merely from a high-paying job, a commodious house and a substantial bank balance. Many cultures promote charitable behaviour and generosity towards the underprivileged, which makes an individual play a key role in the larger scheme of things. Such generosity contributes to not just the spiritual well-being of the person who has a charitable intent, but also to social/economic/environmental well-being in general. How can one measure the 'cultural/heritage/religion-based sustainability'? Any suggestions for one appropriate indicator? I would like to leave it you, the reader, to decide what would be the best way to measure this aspect of social sustainability.

3.4 Happiness not ready-made, stems from one's own actions

This brings us to the elusive criterion of 'happiness'. The sub-heading is attributed to the Dalai Lama. The lead picture, if you refer back to it, includes happiness as an independent criterion. Happiness is usually defined as a 'state of mind'. There need not necessarily be a positive correlation between good health and happiness, or between high education and happiness, for that matter. Affluent and highly-educated people are not necessarily the happiest. The adage – *Ignorance is Bliss* – comes to mind. One is also reminded of the advice *'Contentment is happiness'*.

An indicator 'Gross National Happiness' (GNH), was coined in 1972 by the Bhutanese king Jigme Singye Wangchuck. He also maintained that this was more important than the Gross National Product. GNH was looked upon as overarching and including within its ambit, 'sustainable development', 'preservation of cultural values', 'preservation of environment' etc. By our definition in this book, 'sustainable development' is the collective term and it includes all the sub-processes involved in the pursuit of social, economic and environmental sustainability. We define happiness as a component of social sustainability, and consider it to be influenced partly by economic sustainability and environmental sustainability. Seeking happiness is considered to be a part of seeking sustainability and not the other way round.

We must reiterate here that definite correlations if any between happiness on the one hand, and health, education, culture and employment on the other need to be investigated by monitoring all these aspects of social sustainability over time. While health is 'psychosomatic', education is 'intellectual', happiness is 'mental' – a state of mind, culture/religion may be looked upon as 'spiritual'. These four thereby can be associated with the four different aspects of human existence, from the grossest to the subtlest. Thereby, it would not be wrong to consider happiness to be an independent criterion of social sustainability, and measure it by interacting directly with the people to find out if they are happy/unhappy, and the reasons for the same. Refer Figure 3-3, which charts the four dimensions of social sustainability referred to. Also recall that social sustainability here, can also be looked upon as an aggregate of the sustainability which each one of us is able to attain on a holistic level – psychosomatically, mentally (emotionally), intellectually and spiritually. If it exists on a micro-level, it can wonderfully blossom to the macro-level.

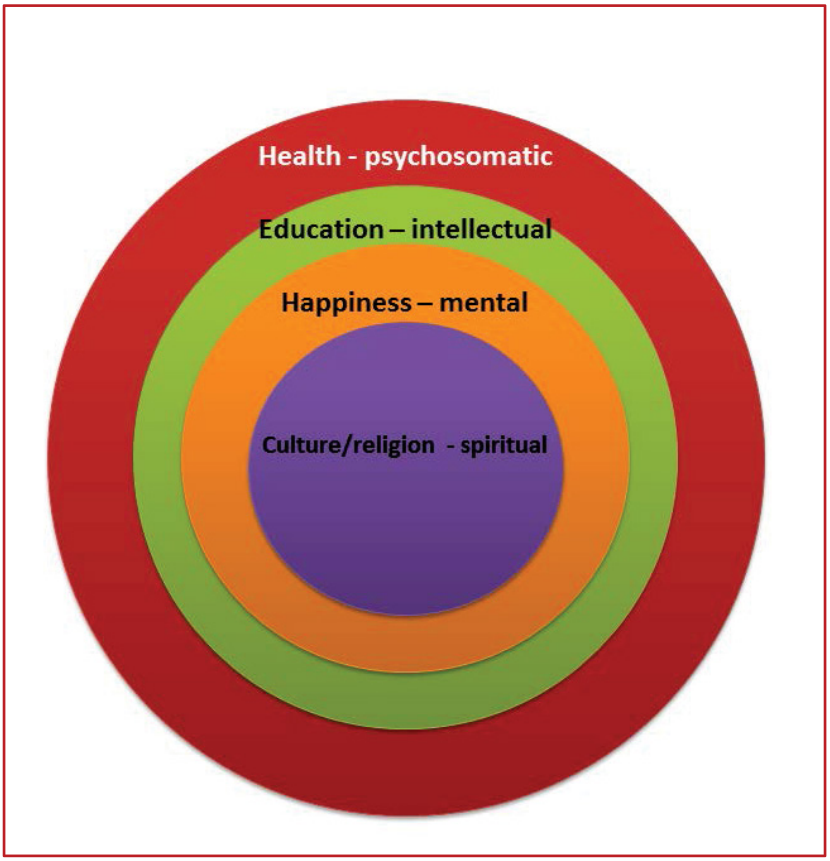


Figure 3-3: The four dimensions of social sustainability – grossest to subtlest

3.5 Social LCA – counterpart of LCC

What Life-cycle Costing is to economic feasibility, a social-Life Cycle Analysis (abbreviated as S-LCA[17]) is to social acceptability. While economic feasibility on a micro-, or meso-level feeds into economic sustainability on a macro-level (by enabling economically-sustainable development), as explained in Chapter 2, social acceptability on a micro-, or meso-level, feeds into social sustainability on a macro-level (by enabling socially-sustainable development).

Any project undertaken by a municipality for instance, can be subjected to an S-LCA to find out how all the stakeholders view it. S-LCA adopts a survey-approach, where groups of stakeholders or their representatives are contacted with questionnaires in order to gauge how they think the project would impact their well-being. Depending upon the type of project, questions can be framed to obtain qualitative or quantitative responses which can be translated into averaged indicators. The indicators can then be grouped under the broad criteria – Health, Culture/Heritage/Religion, Happiness, Employment[18] and Education (Of course, one may define other criteria and have a finer dispersion of the indicators selected). While in an LCC (refer Chapter 1), the Net Present Value is an indicator of the degree of economic feasibility, in an S-LCA, the indicators and the criteria need to be weighted (more about the concept of weighting in a subsequent chapter), in order to obtain an aggregated social acceptability index (say, on a scale of 1 to 10). Benchmarks can be set and decisions taken on the basis of the relation of the index to the benchmark. It follows that what is socially acceptable and implemented, contributes to socially-sustainable development – in other words, the progress towards social sustainability.

3.6 The socio-economic realm

Employment figures in the lead picture of this chapter, but it has been considered as a criterion for the dimension – economic sustainability. It belongs to both the social and economic dimensions for that matter; just like the Gini Index. However, in this book, the author would like to believe that these are more closely related to the economic dimension, and so, should be allowed to stay there. Alternately one may wish to define a new 'in-between' dimension – socio-economic sustainability {the goal which economic or (socio-economic) development would pursue} – and assign these two indicators to that dimension.

3.7 Exercise III

1. Suggest a robust set of indicators to measure social sustainability encompassing all the criteria described in this chapter. Do you agree with the indicators for health suggested in the chapter?
2. Consider a hypothetical case. In a city, there is a very old temple (can perhaps be considered as a heritage site) on a sizable plot of land. You however are not sure how many people value it, or whether it brings in tourist revenue to your city. The city would make do with another school, another hospital, and perhaps even office premises which could be let out to entrepreneurs and perhaps multinational companies which intend to locate their offices in your city. This plot of land is very strategically located – close to the railway station, bus depot and a metro station. You are a decision-maker who believes in change, but at the same time, adopts a holistic outlook to development – in other words, you believe in 'total sustainability'. What would you do? (Hint: No two answers would be the same here).

3. How do the different forms of government – far left to the far right – impact on social sustainability, in general? This is more a political-science question, and goes to show that this discipline is also extremely important in sustainability studies.
4. We talked of a socio-economic realm in this chapter. Employment rate and the Gini Index would fit into one such dimension if it were to be created. Would there be aspects/indicators likewise, fitting into a socio-environmental realm or an enviro-economic realm? Discuss.

4 The planet 'P' – environment

Learning objectives: To understand the environmental component of sustainability, its nexus with the social and economic components, and be motivated to learn more about the tool – Environmental Life Cycle Analysis.

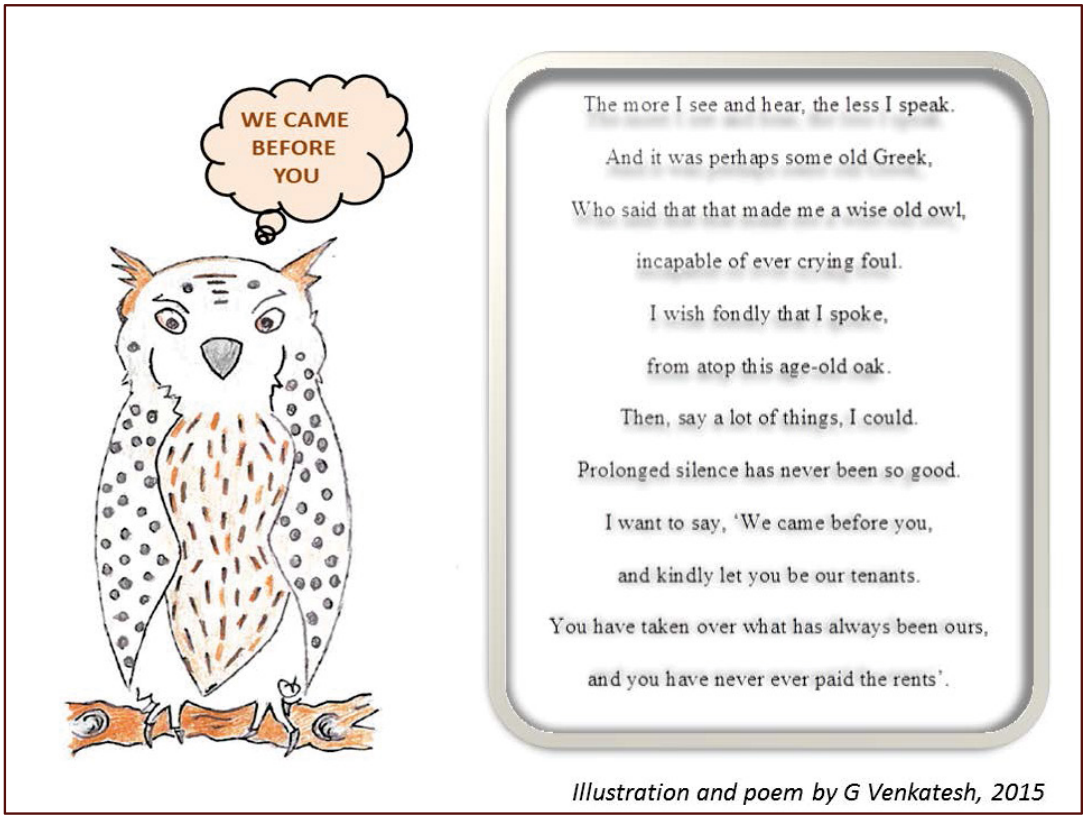


Illustration and poem by G Venkatesh, 2015

The lead picture says it all. We, humans, are beholden to the environment on which we have depended for our existence, and continue to do so. Figure 1-1 shows three meshing gears for the environment – land/soil, air and water. We need to convert this triad into a quartet by adding on the 'biosphere' which interacts with these three. The biosphere essentially has two components – the Flora (with all the plant-life) and the Fauna (the animal kingdom). Humans can be looked upon as comprising the Anthroposphere which has been responsible for the detrimental impacts on soil, air and water, and also on the Flora and the Fauna (Refer Figure 4-1). The double-headed arrows indicate that humans extract valuable resources from the environment (making it the source), and also discharge wastes back into it (making it the sink also). Note that there are interactions among the lithosphere, atmosphere and hydrosphere, which have not been shown in Figure 4.1.

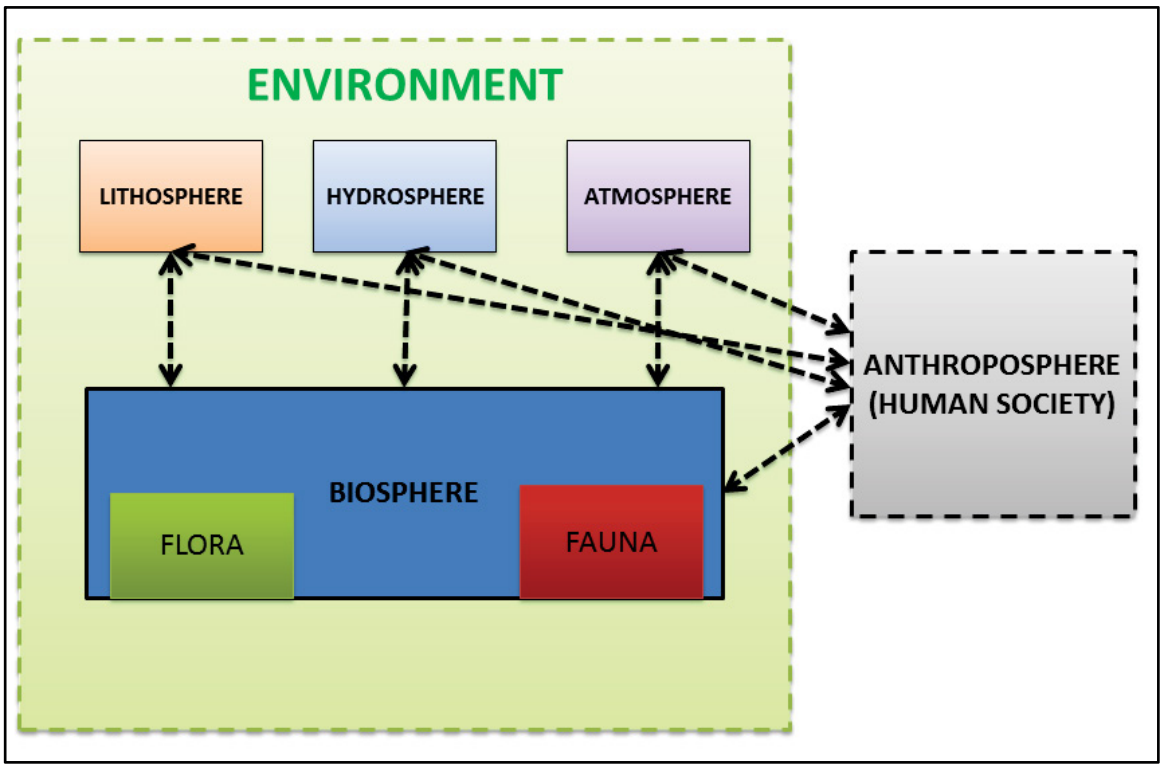


Figure 4-1: The different interacting 'spheres'

Thus, it does not take a lot of intelligence for one to understand that if we need to continue using the environment as a source, we need to be aware of what we are doing to it when we use it as a sink. We can introduce the term 'carrying capacity' here, as the capacity beyond which the ability of a source to provide necessary services to humans (and for that matter, other living creatures as well) is irreversibly compromised. Each unit of the environment has its own carrying capacity, be that lake, river, forest, or for that matter even animal species (in the last case, one could think more of the ability to endure).

4.1 The nexus again

We discussed the nexus between social and economic sustainability earlier. Likewise, there are two more – between social and environmental sustainability on the one hand, and between economic and environmental sustainability on the other. Further, just as we identified a possible socio-economic realm, enviro-economic and socio-environmental realms can also be defined (This is one of the questions in Exercise III which you may already have answered). The analogy to 'going round in circles' and 'running straight ahead' expounded in Figure 3-1, applies to these two nexuses also.

You limit your ability to improve environmental sustainability (or advance further on the path of environmentally-sustainable development), if you adopt favouritism towards social welfare and/or economic growth/development. The converse is also true, to a considerable extent. A 'radically-green' approach to sustainability (which is in no way 'total sustainability'), compromises economic development and some aspects of social welfare. One should not, for instance, opt to take away the comfort which the rich enjoy by driving cars, by resorting to radical measures like bans on cars or making the owning-maintaining-operating of a car ridiculously expensive. The provision of well-functioning public transportation alternatives is not in any way a justification for such radical measures. Honouring the nexus calls for a gradual progress towards a balance, at which point awareness is maximized and there is voluntary adoption of public transportation alternatives on the part of a majority of the population, or at least a voluntary cutback in the percentage of annual travel accounted for by private vehicles.

Likewise, imposing extremely stringent limits right away (by government mandates, violation of which is made a punishable offence) on resource extraction from mines, forests and water-bodies, will derail economic growth and result in a loss of jobs, consequently having an adverse effect on social welfare. The trick here is to pace oneself cleverly and eye the perfect (or near-perfect) balance.

As will be pointed out in the next chapter, to use an analogy to driving, it is all about knowing when to start, when to step on the gas, when to brake and when to turn off the engine and give the vehicle some rest…

4.2 Measuring environmental sustainability

This is all about identifying the degree of damage inflicted on the environment. Humankind, by virtue of its dependence on it, cannot exist without damaging it. However, we can think in terms of minimizing the damage, damage control and obtaining knowledge and awareness about the carrying capacities referred to earlier, which must not be exceeded. All components (or say, compartments) of the environment should be allowed to regenerate themselves naturally, or such regeneration should be induced by human efforts if possible.

Talking of measuring damage, the abbreviation E-LCA (often, simply LCA) is very well-entrenched these days in research circles (academia, government and industry). Environmental Life Cycle Analysis (E-LCA) is the counterpart of S-LCA which we have mentioned in an earlier chapter. E-LCA makes it possible to calculate the life-cycle contributions (positive, in case of avoided adverse impacts and negative, in case of damages incurred) of anthropogenic activities to the environmental media – air, water, soil/land and the flora/fauna. It is beyond the scope of this book to dwell in great depth on this tool. However, while referring to some online sources of information[19, 20] which readers are advised to access to gain more knowledge about E-LCA, a brief description of this tool will be provided in this chapter.

4.3 E-LCA in a nutshell

The author will refrain from describing E-LCA in the conventional manner in this section. The conventional description can be obtained from one of the two references cited in the previous section. While an E-LCA may be the sole end-goal of environmental analysts, we need to bear in mind that this is a book on sustainability and sustainable development, and thereby E-LCA for us is simply one of the many tools which come in handy, while performing sustainability analysis.

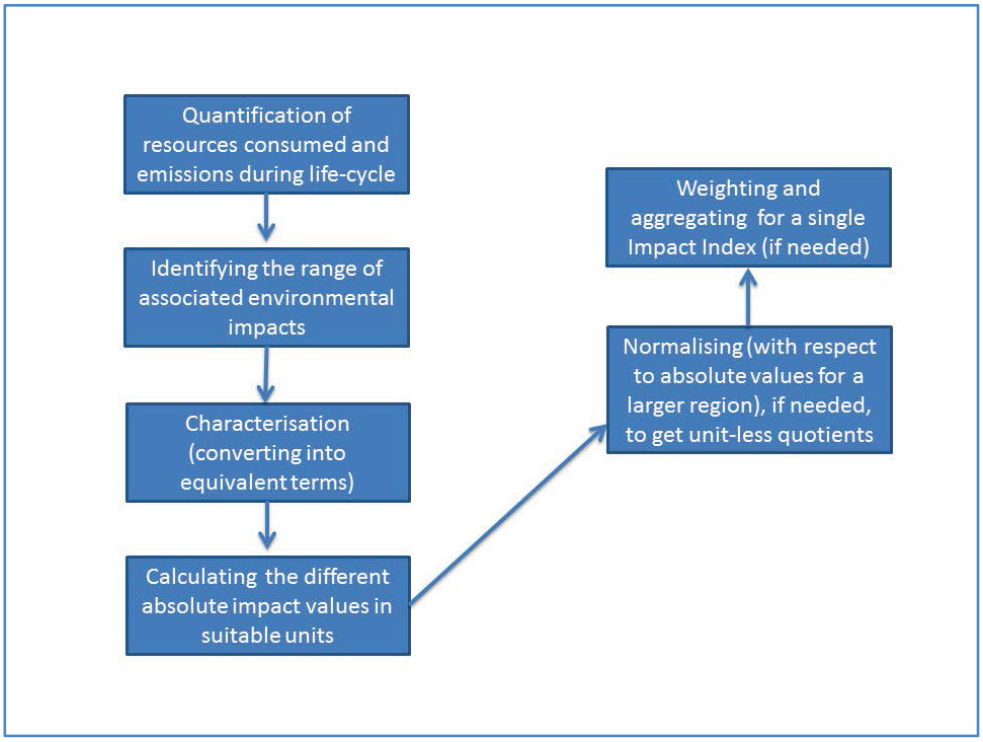


Figure 4-2: The usual steps in a conventional E-LCA

Figure 4.2 will suffice to present the steps which are carried out usually in an E-LCA. Analysts resort to the use of software tools for this purpose[21]. The 'adverse' impact categories referred to in Figure 4-2 are often the so-called midpoint indicators. There are likewise, endpoint indicators as well. The former can be considered to be the agents or the causative factors of the latter. For instance, Greenhouse Gas emissions (GHG emissions) from anthropogenic activities (production and consumption) would be a midpoint indicator, while global warming which is an effect or consequence of GHG emissions is an endpoint indicator. A series of midpoint indicators (acidification, eutrophication, freshwater ecotoxicity etc.) may together cause Ecosystem Damage (in this case, more specifically freshwater ecosystem damage), the latter being an endpoint indicator. Now, one would surely not consider both the causative midpoint indicators and the 'caused' endpoint indicator together in a mix to assess environmental sustainability. It may not be difficult to identify correlations between sets of indicators (the midpoint and endpoint in this case), but it is surely difficult to quantify exactly the degree of correlation or the contribution of each individual causative factor to the final effect. For this reason, the endpoint indicators are not as reliable and accurate as the mid-point ones. In a total sustainability assessment, one may opt to use either relevant midpoint indicators (relevant to context), or endpoint indicators.

Each midpoint indicator adversely impacts one or more of the environmental 'spheres' of Figure 4-1, directly or indirectly. Air, water and soil obviously interact with each other; and flora and fauna depend on all three of them. Hence, it can be said that most of the environmental impacts (midpoint indicators) would end up affecting atmosphere, hydrosphere, pedosphere and the biosphere.

4.4 Mix of 'adverse' and 'positive' indicators possible

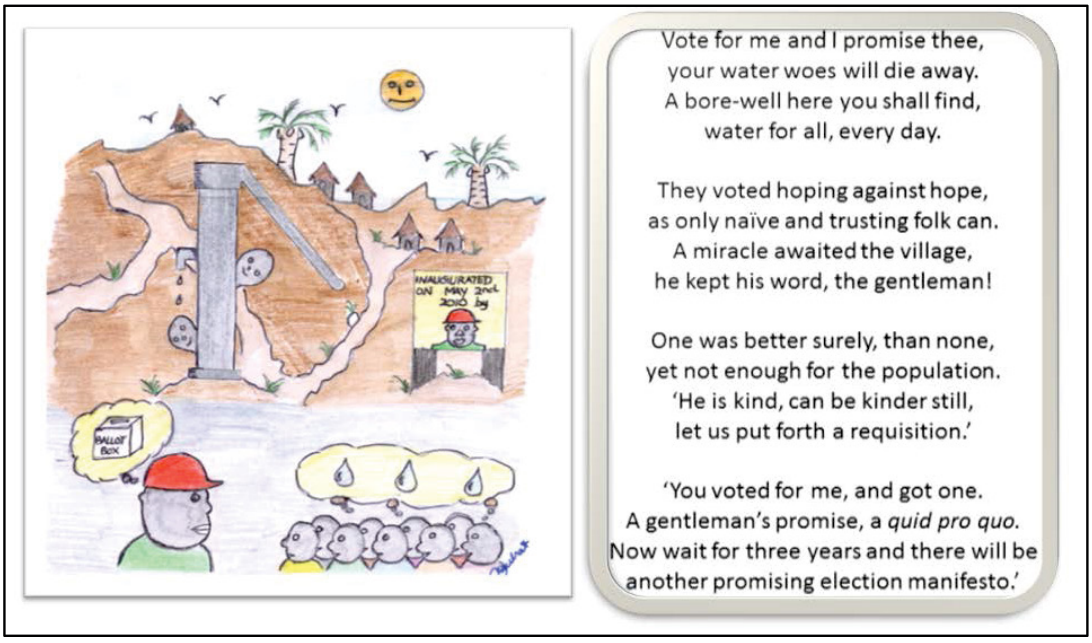
The environmental sustainability indicators need not all be midpoint or endpoint 'adverse' impact indicators. For instance, one may wish to define a 'positive' impact indicator – *Percentage of land area in city allocated to parks and green areas*'. While a decrease in the absolute values of the 'adverse' impact indicators is desirable, one would want to increase the values of the 'positive' impact indicators or at least keep them from sliding down.

4.5 Exercise IV

1. Read more about E-LCA by referring to the links cited in the chapter.
2. Comment on the incorporation of E-LCA into LCC by assigning monetary values to environmental damages, and expressing both economy and environment in monetary terms. Does this provide reliable-enough results for decision-making?
3. Will you assign equal importance to air, water, land/soil and flora/fauna, when you are pursuing environmental sustainability? How would context (time and geographical location) affect your decision? Give examples.

5 Good governance – the lubricant

Learning objective: To understand that good governance is indispensable to total sustainability, and think in terms of including it as a dimension of sustainability.



The lube can in Figure 1-1, depicting governance (or leadership), is indispensable for sustainable development. And yes, this needs to be 'good governance' to make the process proceed in the right direction, at the right rate. The lead picture[22] depicts an instance of what is NOT good governance! If you are an independent analyst, you may wish to add on governance as a dimension of sustainability and base this on the fact that 'good/sustainable governance is external to and a must for economic, social and environmental sustainability'. Thus, you may introduce a dimension outside the triple bottomline well aware of the fact that it is like the driver who is needed in a vehicle (not talking of a driverless Google Car here though) to start, steer, brake, park and accelerate.

Governance can be measured then with indicators like *'Accessibility of the elected officials to the electorate'*, *'Number of days which elapse between the registering of a grievance and its redress'*, etc. The only way to obtain numerical values for such indicators is through a survey of the electorate. A qualitative (scale ranging from Excellent to Very Bad) evaluation which can later be translated into a quantitative one, or a quantitative (rating on a scale of 1 to 5 for instance) one for that matter, will provide a reasonably-good idea to the analyst about what different sections of individuals (or simply different individuals for that matter) think about the ability of the governing body/bodies to strike a good balance among economic development, social welfare and environmental upkeep, through their policies and the subsequent consistent implementation of the same. This is very much akin to the 'Popularity Rating' we often hear of. Of course, the challenge here is to understand the applicability or otherwise, of average values for such indicators. Even if there may be no other way than to use the mean value of the set of responses gathered, knowing the frequency distribution of the responses is essential to determine if an average value can truly be considered to be representative of the family of responses gathered for the population sampled.

Well, while that was what you may do as an independent analyst, you would rather opt not to use the 'governance' dimension if you are carrying out the analysis at the behest of a government agency unless of course the government agency in question expresses its interest in finding out through your study what the electorate actually thinks about the state of affairs.

Sustainable governance thus, lucidly defined, is the willingness on the part of government officials to listen to the grievances of the electorate, weigh the same from the point of view of total sustainable development, prioritise, understand challenges and conflicts among the plethora of concerns, and undertake interventions (could be a wisely-crafted mix of subsidies, taxes and penalties for instance) in the best long-term (or medium-term) interests of society, economy and environment.[23] Accessibility to the people, and problem-solving abilities would thus be the two most-important determinants of sustainable governance. However, the top-down approach alone cannot work wonders to advance a city, region, province or country towards total sustainability. Top-down must also have as one of its responsibilities (or strategies), the devising of ways and means to promote the bottom-up approach (adherence on the part of the electorate to the *sine qua non* for sustainable development, as well as governmental encouragement to initiatives undertaken by the people themselves). If top-down can thus motivate bottom-up, an ideal situation comes to be. At this juncture, a paper from the journal Problemy Ekorozowju would be apt as a cross-reference.[24] As mentioned in the said paper, governance is essentially about being kind to the good and stern with the not-so-good. The author is reminded of the Hindu God of sustenance – Lord Vishnu – who is depicted in paintings and sculptures carrying four objects in his four hands. A discuss (analogously representing the imposition of sanctions or discrimination), a mace (standing for the levy of fines and penalties), a conch (symbolizing incentives or warnings) and a lotus (depicting exhortation, appreciation and reward). Administrators too can learn a lot from mythology, if they approach it with their eyes and ears open! Good, committed and responsible governance is a key to sustainable development. Sometimes, 'governance' may be referred to as the 'political' dimension of sustainability. It should however be pointed out here that governance transcends and supersedes politics. If the former is leadership, the latter is, at best, management. Readers know the difference between these two, for sure.

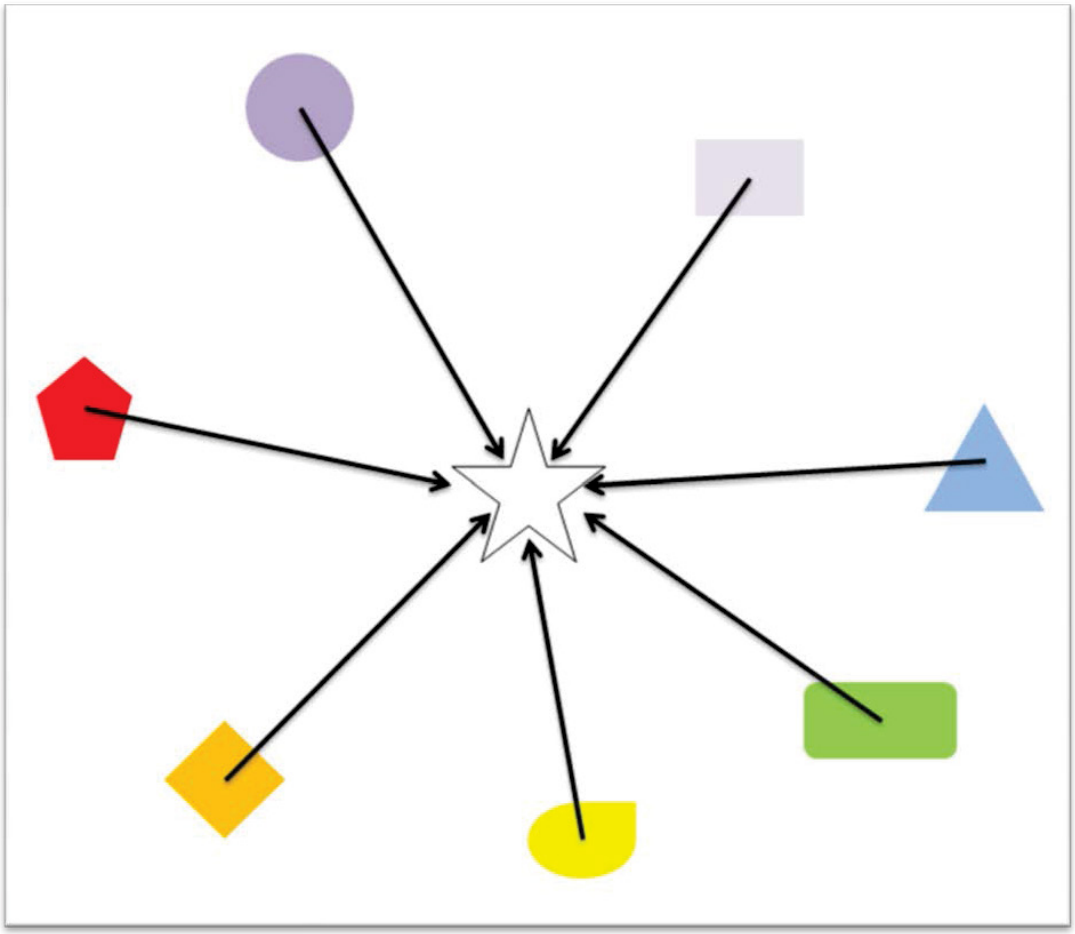
More on how total sustainability (on city, regional and national levels) can be mapped on to individual or personal sustainability, in the next chapter. *En passant,* reference can be made to a deliverable of the European Union project TRUST – Transition to the Urban Water Services of Tomorrow – in which governance was suggested as a dimension (in addition to Social, Economic, Environmental and Assets) of the sustainability of urban water utilities.[25]

5.1 Exercise V

1. Define suitable governance indicators (you do not need to abide by what have been recommended in the chapter). Chart out a structured plan of how one can go about obtaining values for the same. If you have a set of indicators under this criterion, decide on how you will go about weighting or prioritizing these? Consider that you are performing this analysis for your home city, and thereby you know the context pretty well.

6 Integration is key

Learning objectives: The word 'integration' here applies to both the methodology of the sustainability analysis, and also on a broader, practical and philosophical level to the fact that individuals need to integrate themselves into the larger picture of sustainability by making conscious attempts to reach 'individual sustainability'. Readers get to know how one could combine the different sustainability categories into one single Total Sustainability Index.



6.1 The methodological integration – weighting and aggregation

The following is a modified extract from the author's PhD thesis[26]. In the original version, a fourth dimension called 'Functional' had been considered in addition to the triple-bottom-line. For the sake of simplicity, it has been excluded from the modified version presented hereunder. However, the author would like to reinforce the understanding that the choice of the sustainability dimensions and the indicators thereof, is entirely subjective (based on context and objective), and rests with the analyst.

Once the indicators (social, economic, environmental and maybe governance) are grouped, it is essential to ponder over the importance or otherwise, of aggregation. Of course, one may opt not to aggregate and then the whole idea of a Total Sustainability Index (TSI) will collapse. However, if it is deemed to be wise to calculate the TSI, suitable weighting factors for indicators under every criterion and for the criteria themselves, reflecting the relative degrees of importance of the different aspects of sustainable development, need to be assigned. (Note that weighting/prioritization will always remain a debatable issue). The absolute values of the indicators are normalised with respect to a base or reference year in the past. One then obtains quotients by dividing the values for the year of interest by the corresponding values for the reference or base year with which the comparison is being made. This is very apt and appropriate as sustainable development essentially aims at improvement and betterment over time. This improvement could be interpreted as either an increase or decrease in the value of an indicator – and this depends on what is being measured by the indicator (Refer Figure 7-1).

The weighted averaging could be done geometrically, arithmetically or as a blend of both methods. When the averaging is done, for every quotient Q taken into consideration, attention must be paid to whether an increase or decrease in the quotient is beneficial and desired. When an increase in the value of Q is desirable, Q is used directly in the averaging process whatever its value. If an increase is not desirable, the reciprocal of Q is used. Thus, by definition, an increase in the value of the Total Sustainability Index above unity (which is, in effect the Index for the reference year), is deemed to be a movement towards sustainability and a drop below unity is considered to be a movement away from the 'moving target'.

The logic behind the application of the IF-THEN statements of Figure 7-1 can be understood with simple examples. We start off with the premise, as referred to earlier, that a decrease in the Total Sustainability Index to a value less than 1, is not desired. If the value of the indicator for year-2010 is being compared to that for year-2006 for instance; and the quotient Q is obtained by dividing the former by the latter, we can consider four hypothetical possibilities to understand Figure 7-1 better.

a) Say for instance, the indicator is the *energy consumed per unit production in a certain industrial sector.* Then, a decrease in this indicator is certainly desirable. So, if Q is less than 1, an improvement is indicated. Including the reciprocal of this in the summation will contribute to increasing the value of the Index, which, as mentioned in the premise, signifies a move towards sustainability.
b) The indicator is still *energy consumed per unit production*, and the value of Q is greater than 1. This is certainly not desirable. Including the reciprocal of Q now, will contribute to a drop in the value of the Index, and that is a move away from sustainability.
c) If the indicator being considered is the *literacy rate*, an increase in the same over time is desirable. Or in other words, a reduction is not desirable. If Q in this case decreases, it is not acceptable. So, Q is considered in the summation.
d) Considering the same indicator as in (c), if Q increases – in other words, the literacy rate increases in year-2010 over that in year-2006 – it is an improvement. We would then still take the value of Q as-is, and in keeping with the premise, a value greater than 1, indicates a movement towards sustainability in year-2010, with respect to year-2006.

In the four equations below, the subscripts – 's', 'e', and 'ec' – stand for social, environmental and economic respectively; WGM stands for the weighted geometric mean, and WAM for the weighted arithmetic mean; 'a', 'b' and 'c' are the weighting factors respectively for the social, economic and environmental sustainability criteria, such that the sum of the four factors is 1. (TSI stands for the Total Sustainability Index, and the word within the subscripted parentheses indicates the approach adopted to calculate it). The 'hybrid1' approach calculates the WGM of the WAMs, while the 'hybrid2' approach does the converse.

$$TSI_{arithmetic} = WAM_s * a + WAM_{ec} * b + WAM_e * c \quad \textbf{- (Equation 6-1)}$$

$$TSI_{geometric} = (WGM_s)\text{^}a * (WGM_{ec})\text{^}b + (WGM_e)\text{^}c \quad \textbf{- (Equation 6-2)}$$

$$TSI_{hybrid\ 1} = (WAM_s)\text{^}a * (WAM_{ec})\text{^}b + (WAM_e)\text{^}c \quad \textbf{- (Equation 6-3)}$$

$$TSI_{hybrid\ 2} = WGM_s * a + WGM_{ec} * b + WGM_e * c \quad \textbf{- (Equation 6-4)}$$

As you will read again in the next chapter, weighting factors are usually not constant over time. Such factors are usually aligned closely with the realities-on-the-ground and policies formulated by governing bodies. Thus, it follows that they need to be re-examined from time to time – both the indicators themselves and their weighting factors. Re-evaluation is necessary as some indicators may cease to be of importance after some time (and may have to be excluded or down-weighted). New challenges would then call for reformulation in the policies, and thereby the definition of new indicators. Weighting factors are subjective but at least they are explicit. Otherwise, priorities are set implicitly, and sometimes inadvertently, by the push and pull of politics. Combining these dimensions into a single score by which countries can be compared, also concentrates minds.[27]

However, it must be acknowledged that quantifying sustainability by resorting to the use of indicators may lead to losses of important qualitative information which would have enhanced system understanding[28]. With an increasing degree of aggregation, information relevant to practical decision-making gets obfuscated, and the purpose of aggregation itself stands defeated. But, a given piece of information or processed data is useful in different forms to different entities for different purposes. Aggregation, it can be said, is meaningful and purposeful if it does not supplant the need for disaggregation, as and when required. This is quite akin to the aggregated environmental impact score in E-LCA studies where the normalization and weighting factors introduce a lot of subjectivity to the final result. Current practices of benchmarking and target-setting identify and measure selected indicators against preset benchmarks or targets – which can of course be continuously changed for progressive improvement. Aggregating the indicators by weighting and prioritising is generally not considered to be practical.

A point, worth pondering over, needs to be mentioned here as regards the selection of indicators. If a secondary indicator Y is perfectly correlated with a primary indicator X (and only indicator X), would it be wise to include both in the mix and provide a non-zero weighting factor for Y? Will not one then end up, in a way, either overestimating or underestimating, or making no difference to the TSI calculated using the mix of indicators selected?[29] A question in the Exercise at the end of this chapter prompts you to read the paper cited in the previous sentence and discuss this fact.

6.2 The philosophical 'integration'

This section is adapted from a published journal paper[30]. What follows essentially is an interpretation of Figure 6-1. Physical development – proper nourishment, active lifestyle and temperance *inter alia* – contributes to a capacity for hard work, which translates into economic gains. Man works hard and long, earns and pays (taxes, costs of living, salaries to employees etc.) and contributes to the virtuous chain of growth. Physical vitality manifests as money which turns the gears of economic development. However, no individual even though he may be strong and robust, can move mountains without garnering the support of fellow human-beings. This is where the mental-emotional-psychological component of individual development comes in. Co-operation and co-existence are *sine qua non* for a civilized society. Social growth is impossible without emotionally mature and wise citizens who live and let live, abide by rules and regulations, help each other, and stand up united to quell anti-social elements that threaten peace and harmony.

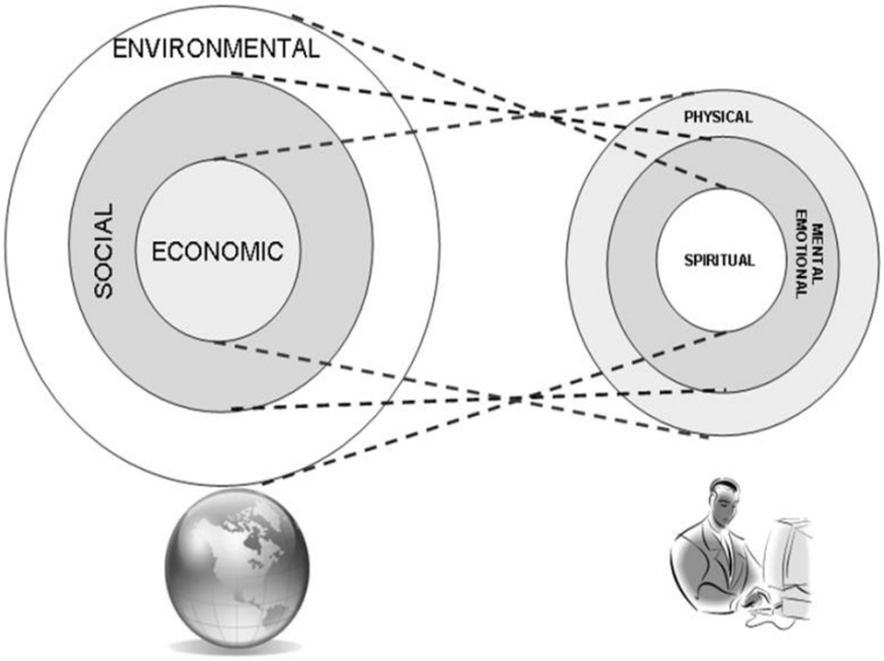


Figure 6-1: Mapping individual sustainability to global sustainability[30]

Culture, education, art and language – different manifestations and expressions of the mental, emotional and psychological – also play a positive role in social development. Here, when one talks of citizens, one also refers to the administrators/politicians who run the society. The definition of 'society' here is subjective. One may refer to a village, city, province or country or for that matter the whole interconnected world taken together and referred to as the Global Village. Spiritual growth which usually follows the other two entails the acceptance of the fact that each one of us is an infinitesimally-small stitch in the fabric of the universe; yet contributes to making it work shipshape. The realisation that *the earth does not belong to man, man belongs to the earth; all things are connected like the blood which unites family,* (attributed to Chief Seattle's 1854 speech in the 1972 Hollywood film *Home*, and also used by Al Gore in his 1992 book – *Earth in the Balance*); that it is a home one would rent for a while before leaving it for good; that one has a responsibility towards leaving it better than how it was when one occupied it, entrenches itself firmly as man ascends the ladder of spiritual advancement. Spirituality is the end-goal of all religions. However, it is worth pondering over the hurdles posed to sustainable development, by religious dogmas and ceremonial rituals. The 'earth' referred to above includes everything other than human beings and anthropogenic systems; and thus is synonymous with the environment in which human beings live and work (Refer Figure 4-1). It follows that the environment is the home in which everyone dwells and the upkeep of which, all of us are responsible for. Spiritual growth thus, can be said to be analogous to environmental sustainability. Quite similar to spiritual growth which demands greater efforts, the later one starts on the path leading to it, greater are the costs of corrective action to undo or mitigate the damages done to the environment. This makes prevention better than cure, and the present, the best time to act. The subtlest for an individual is also all-encompassing and the most difficult to comprehend and attain to. The grossest is the easiest to cater to – materialistic pursuits to pander to the sense organs. The analogy to the environment is easy to grasp – overlooked and prejudiced against, at the altar of consumptive growth and affluence (bias in favour of socio-economic development).

Refer Figure 6-2[31] which illustrates the Levels of Quality described by Robert Pirsig in his book 'LILA-An enquiry into morals'. What follows is an adapted excerpt from the paper cited, which readers may wish to read (available online on the website of Problemy Ekorozwoju). The hierarchy in the levels is evident from the illustration. Further, every higher one is distinctly superior to the one beneath it. Being superior, it also controls and dominates the lower one. However, even though it has the power to exert control and dominance over the lower one, the higher one, in a system which is ideal and well-functioning, should not and does not destroy it for its own sake. It has to actually nurture and maintain it as it depends on it for its own sustenance. The paradox in this statement can be resolved instantly by thinking of the theme of this very book – sustainability. Natural Quality or Natural Value is that which has existed even before Biological Quality (as applied to human beings), Social Quality (as applied to communities, settlements, villages, towns and cities) and Intellectual Quality (as applied to art, literature, education, science and technology) appeared. The air, water, soil, mineral resources, flora and fauna are more primal in nature, *vis-à-vis* the ones which have built themselves upon it. Very similar to the foundations of an edifice, it is this Natural Quality which sustains the evolving Biological, Social and Intellectual Quality levels, which flourish in the edifice above. The Natural Quality is essential for growth – it is essential as the bedrock for human existence and source of nourishment for human survival. An improvement in Biological Quality necessitates a deterioration of Natural Quality, over time. After a given point, the improvement becomes unsustainable because of the said dependence.

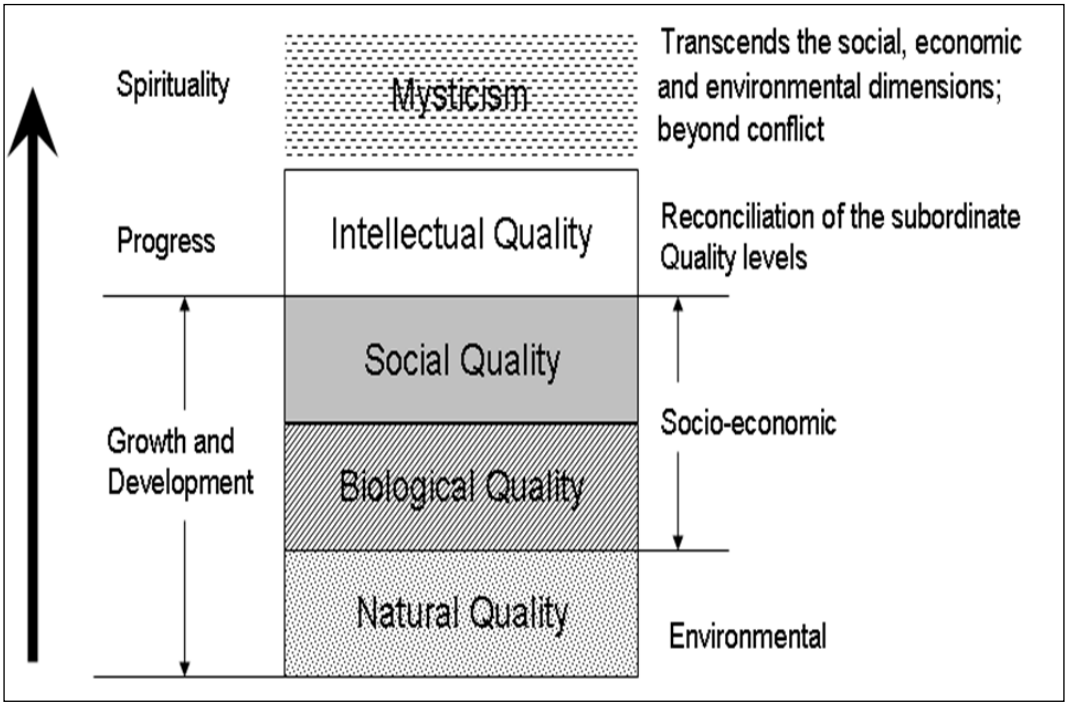


Figure 6-2: Sustainability interpreted in terms of Quality level[31]

The Social and Intellectual Quality levels which are associated with the Heart and Mind of mankind[30] are on higher rungs of the development hierarchy. If these two stagnate, growth collapses to decay. There are limits to growth in the absence of 'development' (recall the difference between these two terms from an earlier chapter). Social Quality here represents policies, rules and regulations which restrict while not being repressive. Social Quality may be looked upon as a fraction of the Biological Quality becoming more powerful than the others, and exercising the right of might. At such instances, to sustain development and enable it to manifest as true progress, Intellectual Quality needs to step in. Again, this would be a small part of Social Quality rising up and becoming Intellectual Quality. This speaks a universal language – through the media of science, technology, art, philosophy and literature. Thus, from growth to progress, we move from the gross to the subtle, or the more-gross to the less-gross. Control and domination which we associate with the lower strata of Quality fall away and an awareness of the spiritual Self is felt. Intellectual Quality attempts to preserve the Natural, Biological and Social, as without such preservation, the ascent to the top would become impossible for the generations to follow. Sustainability is impossible without any of these. Mysticism – the final rung on the ladder of Quality is beyond Quality, if that statement makes sense. While Biological, Social and Intellectual Qualities use the Body, Heart and Mind respectively to sustain and self-propagate, mysticism uses the Soul and appreciates the interrelatedness of the quality-levels in a spiritual sense. Just as spiritual advancement aids respect for the environment (Figure 6-1), mysticism comprehends Natural Quality in its entirety, and gets a glimpse of the subtlety concealed behind the veneer of grossness. In a perfectly self-regulating system, the higher controls ought to be essentially enablers with a purpose to serve.

6.3 Exercise VI

1. Access the following paper (from ResearchGate) – **Venkatesh, G. A critique of the European Green City Index, *Journal of Environmental Planning and Management*, 57:3, 317–328, 2014.** Write a critique of the same (600–800 words). Focus on the aspect of overestimation, underestimation or no-change, raised in the chapter, when there are strong correlations among indicators. Is this thought valid at all?
2. As far as the various ways of aggregation are concerned (arithmetic and geometric means), do you think that these have relative merits and demerits?

7 Sustainable development as a single measure: Case study of some developing Asian countries[32]

Learning objectives: This is just to demonstrate to readers how sustainability can be converted from something abstract to something measurable, purposeful and useful. The flags in the lead picture below belong to those Asian countries which have been selected as cases for this chapter/paper.

7.1 Abstract:

The Rio Earth Summit of 1992 had emphasized on the development of suitable indicators for the measurement of sustainable development, as aids for decision-making at all levels. In this paper, the authors demonstrate how a Holistic (Total) National Sustainability Index can be constructed, by taking into consideration four dimensions of sustainability – Social, Economic, Environmental and Infrastructural. The methodology is applied to 12 developing Asian countries, where sustainable development is vital in the years to come. Comparison among countries using their respective Indices would be meaningless; it is not the 'states' the countries are at a given point in time, but the 'paths' which they follow over time, on the sustainability curve, which are comparable. Limitations and subjectivity notwithstanding, such an Index when used on its merit (with complete understanding of its deficiencies), can be a good planning tool for decision-makers at all levels of government.

7.2 Introduction and literature review

Sustainability is a condition or a state, while sustainable development is a process or a set of strategies which when implemented, is supposed to take one towards that state. Being a moving target, sustainability needs to be pursued anew every time the factors influencing it keep changing. European Communities (2007) is one of the many publications in which this distinction is brought out clearly. As Kallio, et al (2007) has said, the phenomenon we label as sustainable development can never be exhaustively defined; it would constantly change with time, interpreters and their needs. We thus have an elusive, impermanent end-goal, which is pursued with a changeable set of ways and means. Quental, et al (2011) has stated that the introduction of sustainable development as a concept was an intellectual answer to reconcile the conflicting goals of environmental protection and economic growth. Pawlowski (2008) emphasizes on the fact that technology alone cannot solve the problems which the world encounters in the 21st century. The social and economic aspects of sustainable development need to be factored in.

Ehrenfeld (2009) has said that when one talks about sustainability, one is usually expressing a desire to maintain some emergent property over long periods of time. The paper refers to it as a 'meta-quality'. Guha (1992, p. 60) has talked about 'orderly growth; not growth at the expense of order or for that matter, order at the expense of growth.' The abstractness associated with it can be concretised to some extent by identifying and defining certain indicators – by following the processes of conceptualisation and operationalisation commonly used in the social sciences (Singhirunnusorn and Stenstrom, 2009). An indicator, as an OECD report defined it (Keirstead and Leach, 2008), is a parameter or a value derived from parameters, which points to, provides information about, and describes the state of a phenomenon/ environment/area, with a significance extending beyond that directly associated with the parameter value.

To understand the status quo that prevails at the time of writing, one would need to relate it to the past for what obtains now is the sum total of all that has been and occurred in the past. It is here that a time-series analysis – a peep into history so to say – becomes important. Having seen and understood the present with respect to the past, the future course of action (course corrections in other words) can be planned. As Cameron and Neal (2003) believe, 'A correct diagnosis of the origins of a problem does not in itself guarantee an effective prescription but without such a diagnosis one can scarcely hope to remedy the problem.' Singhirunnusorn and Stenstrom (2009) have defined seven principles at the top of the hierarchy. Sustainability – considered as an environmental aspect – is one of them. On the second rung are criteria and on the last, measurable indicators.

In 2009, the Economist Intelligence Unit (London, UK), sponsored by Siemens (Germany), published the European Green City Index report (Economist Intelligence Unit, London 2009). A total of 30 cities (most of them capital cities of European countries) were studied under eight different categories: Carbon dioxide; Energy; Transport; Water; Environmental Governance; Waste and land use; Air quality; and Buildings. In total, these eight categories were composed of 30 indicators. As Venkatesh (2012) advocates, a blind pursuit of a higher Green City Index is certainly not to be recommended, but rather an integration of the Green City Index with a Socio-Economic Index. City authorities could use the knowledge of the inter-linkages and correlations among the different indicators (and Indices) to chart the course ahead, while ensuring that complementarities and synergies are fully harnessed. In Venkatesh and Brattebø (2012), the authors have recommended the classification of cities into city types based on specific attributes and identification of relevant environmental sustainability indicators – for urban water and wastewater systems in particular – from a pool of 13 indicators, for these different city types.

There is the Multi-dimensional Poverty Index (MPI) developed by Sabina Alkire and her colleagues at the Oxford Poverty and Human Development Initiative (The Economist, 2013A, p. 71). MPI considers poverty to be three-dimensional – Health, Education and Living Standards equally-weighted – and defines ten indicators in all. The Index's defenders point out that the weighting factors may be arbitrary, but at least they are explicit. Otherwise, priorities are set implicitly, and sometimes inadvertently, by the push and pull of politics. Combining these dimensions into a single score by which countries can be compared, also concentrates minds. Alkire says that when the MPI is adopted, countries like Uganda and Rwanda seem to show marked development as far as reduction of multi-dimensional poverty is concerned; while the simplistic USD 1.25 per day measure paints them in a relatively poorer light.

Five indicators – maternal health, children's well-being, educational status (of mothers), economic status (of mothers) and political status (of mothers) – are aggregated together by the NGO Save the Children in State of the World's Mothers – 2013 (Save the Children, 2013), to arrive at a Mother's Index for 176 countries of the world. The United Nations Development Programme has its Inequality-adjusted Human Development Index (UNDP), which takes into account Income, Life-Expectancy and Education.

The World Bank also developed the Logistics Performance Index (LPI) in 2010, with the criteria being Customs, Infrastructure, International shipping, Logistics, Tracking & Tracing and Timeliness. Among Asian countries, Singapore and Japan figured in the top 10, with scores of 4.09 and 3.86, out of a maximum of 5. China's LPI was 7th in Asia and 27th in the world, while Malaysia was 8th and 29th respectively (Venkatesh, 2011). Talking of infrastructure and the role it plays in sustainable development, it is apt to mention at this juncture that the value of the infrastructure stock in China and India, in year-2012, was 75% and 58% of their respective GDPs in the said year (the average of big economies is around 71%) (The Economist, 2013B, p. 9).

In this paper, the authors demonstrate how a Total (National) Sustainability Index (TSI) can be constructed, by taking into consideration four dimensions of sustainability – Social, Economic, Environmental and Infrastructural. The methodology is applied to (tested on) 12 developing Asian countries, where sustainable development is vital in the years to come. The total population of these countries (which include China, India and Indonesia) accounts for nearly 50% of the total global population. These countries have been categorised into three groups – Low Income (3 – Nepal, Cambodia and Bangladesh), Lower-Middle Income (6 – India, Sri Lanka, The Philippines, Vietnam, Indonesia and Bhutan) and Upper-Middle Income (3 – China, Malaysia and Thailand), based on the classification scheme adopted by the World Bank (also refer Appendix I). It should also be noted at this juncture that comparison among countries using their respective Indices would be meaningless; it is not the 'states' the countries are at a given point in time, but the 'paths' which they follow over time, on the sustainability curve, which are comparable.

7.3 Methodology

It is in keeping with the need for an integrated approach referred to in the previous section, that this paper takes a holistic approach to defining sustainability and calculating a Total Sustainability Index (TSI). Infrastructure development is the key to social welfare and economic growth. It may have both positive and negative impacts on the environment. Investments in infrastructure development are primarily policy-decisions at the level of national and provincial governments. It thus follows that good governance and effective policymaking are *sine qua non* for sustainable development. The four dimensions considered for the purpose of this paper are Economic (E), Social (S), Environmental (EN) and Infrastructural (I). Note that 'Infrastructural' for that matter, fits perfectly into what one may term as a Socio-Economic dimension[33]: some of the infrastructural indicators selected in this paper are closer to social welfare, while the others lean more towards economic growth. The indicators selected under each of these, are numbered as E1, S1, EN1, I1 and so on. In order to differentiate among the values of the same indicator for different years, the year is added on as a subscript to the notation. For the reference year, the values of all the indicators equal 1 (actual value in baseline year divided by itself). The values of the suitably-subscripted indicators for the years following the reference year are obtained by dividing the actual value for the year under consideration by the value in the reference year. Table 1 lists the 18 selected indicators under the four dimensions considered, with their notations, and also categorises them on the basis of whether an increase in the normalised indicator value is desirable for sustainability or not. Primary, secondary and tertiary sectors, in addition to trade-balance are accounted for, under the economic dimension. Household consumption, literacy, access to water and sanitation facilities, life-expectancy at birth (males and females) are considered under the social dimension to encompass health, education, and well-being. Quite contrary to the usual hackneyed focus on GHG emissions when it comes to environmental performance, the canvas is spread out a little wider to include water (fertiliser consumption which influences eutrophication of water bodies, serving as a proxy), atmosphere (GHG emissions), flora and fauna (terrestrial and marine protected areas) and renewable content of the electricity mix (which has far-reaching effects on land, water, soil in general). As far as infrastructure is concerned, electricity generation (which influences economic development and social welfare; while possibly having a negative impact on the environment depending on the sources availed of), transport and communication (motorable roads and telecommunication facilities, which are extremely vital in present-day Asia to connect seller to buyer, labour to worksites, supply to demand) are taken into account. The authors are of the contention that this selection of 18 indicators lends, by and large, a degree of holism to the definition of 'sustainable development'.

Quite obviously, an increase in the value of an indicator like GHG emissions per capita, is unsustainable, while an increase in the literacy rate is very much desirable for sustainable development. (Refer Appendix also). The data were sourced from the website of the World Bank in March 2013, by accessing each individual country page and downloading the Excel file with the time series of data for a long list of indicators. The time period to which the authors restricted themselves was 2003 to 2010. For some countries, owing to non-availability of comprehensive data, the time period was contracted a little to 2003–2009. Gaps in the data streams were filled up by resorting to other sources/contacts – *indexmundi.com,* for instance. Some simple assumptions had to be made. For instance, if the data for the percentage of paved roads is available for year-2004 and year-2008, and there are gaps for the 3 years in between, a linear change is assumed from the 2004–2008 period (increase or decrease as the case may be). Also, for example, if data are not available for the last 2 years of the time period, years 2009 and 2010, then the value for year 2008 is assumed to hold for these years. Likewise, in cases of non-availability of data for say years 2003, 2004 and 2005, the value for year-2006 is assumed to hold for them. Data for the adult literacy rate (% of population above the age of 15) are quite scarce. In cases where there are no responses to data-requests made to government agencies in the respective countries, a similar approach as described above is adopted. This, no doubt, reduces the accuracy of the final results gleaned from the analysis. The assumptions are resorted to, for want of a better way to confront these data gaps. However, this approach is adopted for only those indicators which are measured as percentages.

The author despatched an e-mail questionnaire to researchers and other professionals originating from some of the countries analysed, in October 2013. The purpose was to collect opinions from the respondents about the weighting factors – intra-dimensional and inter-dimensional. Policymakers in the Asian governments, needless to mention, were not accessible to the authors. Policymakers in democracies are elected by the people – directly or indirectly. However, it is not always so, that they represent the will or opinions of the electorate faithfully. Hence, this exercise of reaching out to educated people to collect sets of weighting factors is tantamount to a 'direct-democracy' approach, through which decisions can be made and policies formulated on the basis of the knowledge of what the people opine. In order to render more meaning to the rationale of this approach, it would ideally be necessary to reach out to vast swathes of the populations of the countries studied. That, needless to say, is difficult. Besides, the possibility that some or most of the requests sent (by e-mail) will go unanswered also has to be accepted. All the respondents have spent 20 years or more in their respective countries of origin, and thereby have the credentials to opine about the relative weighting of the different indicators, keeping the state of affairs in their respective countries in mind. Appendix lists the names, nationalities, ages and years-resident-in-country-of-origin of the respondents. Some admitted that it was very difficult to assign the weightages, thus reflecting the inevitable difficulty which policymakers find themselves in, if asked to do so.

For the purpose of this paper, one response per group (Low Income, Low-middle income and Upper-middle income) is deemed to be sufficient. If multiple responses are received, per group, averages are considered. (The respondents have been acknowledged at the end of the paper) Often, one debates and discusses the relevance of one set of weighting factors prescribed for one particular country, to another one. But it is often widely believed that an aggregation of the weighted scores is a more convenient way of comparing and contrasting, when decisions need to be based on a very wide range of criteria.

Increase in normalised indicator value desirable		**Decrease in normalised indicator value desirable**	
Notation		**Notation**	
E1	Economic value added by primary sector (agriculture, fishing, forestry etc.)	EN1	Specific fertiliser consumption (per hectare of arable land)
E2	Economic value added by secondary sector (manufacturing etc.)	EN3	Carbon dioxide emissions per capita
E3	Economic value added by tertiary sector (services)		
E4	Export-import ratio		
I1	Electricity generation per capita		
I2	Percentage of paved roads		
I3	Mobile cellular subscriptions per 100 people		
I4	Telephone lines per 100 people		
EN2	Percentage of renewable content in electricity mix		
EN4	Percentage of terrestrial and marine protected areas		
S1	Household final consumption per capita		
S2	Adult literacy rate		
S3	Percentage of population with access to improved water source		
S4	Percentage of population with access to sanitation facilities		
S5	Life expectancy at birth (female)		
S6	Life expectancy at birth (male)		

Table 7-1: Listing and categorisation of the indicators selected

(Figure 7-1) adopts weighted arithmetic averaging of the normalized indicators within each dimension, followed by weighted arithmetic averaging again of the component indices of the total sustainability index (abbreviated as TSI earlier). It must be mentioned at this juncture that whether to use the normalized indicator (Ei, Si, ENi or Ii) or its reciprocal (1/Ei, 1/Si, 1/ENi or 1/Ii) in the summation is to be decided with reference to Table 7.1 and the flowchart in Figure 7.1.

$$TSI = W_E \sum_{i=1}^{n} w_{Ei} * Ei\left(or\ \frac{1}{Ei}\right) + W_S \sum_{i=1}^{m} w_{Si} * Si\left(or\ \frac{1}{Si}\right) + W_{EN} \sum_{i=1}^{j} w_{ENi} * ENi\left(or\ \frac{1}{ENi}\right) + W_I \sum_{i=1}^{k} w_{Ii} * Ii\ (or\ \frac{1}{Ii})$$

(Equation 7-1)

In the Equation above, TSI is the Total Sustainability Index for a given year. W_E, W_S, W_{EN} and W_I are the weighting factors for the four component indices – economic, social, environmental and infrastructure respectively, such that the sum of these four equals 1. The notations 'n', 'm', 'j' and 'k' (the limits of the four summations), stand for the numbers of indicators within the Economic, Social, Environmental and Infrastructural dimensions respectively. Ei, Si, ENi and Ii, as mentioned above are the normalized 'i^{th}' indicator values for the given year. The weighting factors for these indicator values are w_{Ei}, w_{Si}, w_{ENi} and w_{Ii} respectively, such that the weighting factors in each of the four dimensions ('n', 'm', 'j' and 'k' in number) sum up to 1.

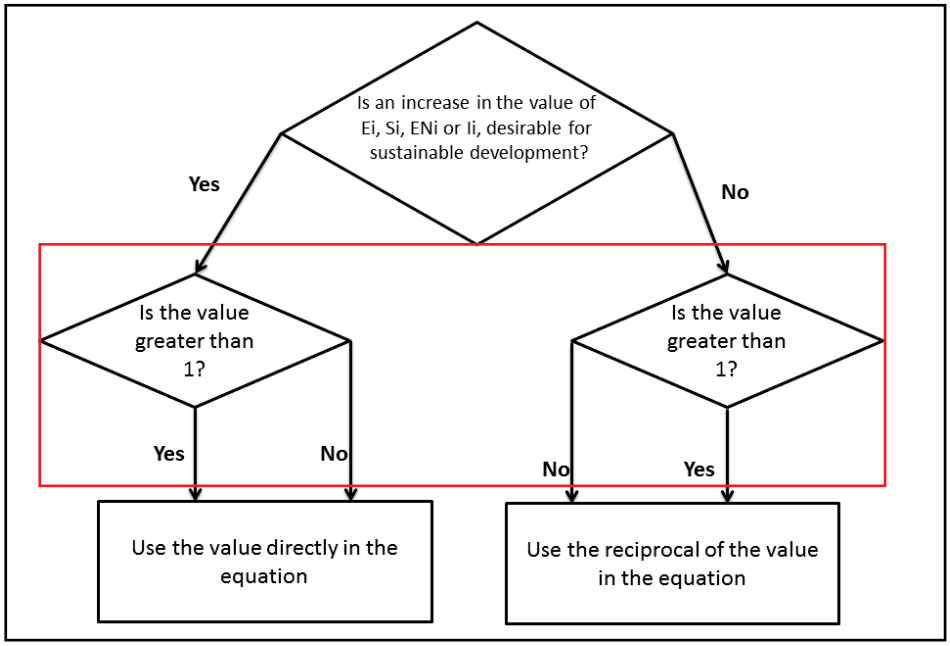


Figure 7-1: Flowchart to explain the choice between the quotient or its reciprocal in Eq 1

As the concept of a total sustainability index (TSI) is relatively new, there is scope in this paper to suggest the use of a geometric weighted averaging approach instead of an arithmetic weighted averaging one. In fact, one could adopt a hybrid averaging approach. The individual indices for the criteria can be obtained by geometric/arithmetic averaging and the final holistic sustainability index may be calculated thereafter by arithmetic/geometric averaging. However, the authors would like to leave these at this juncture as suggestions and not venture into calculating the TSI using these three alternate methods.

7.4 Results and discussions

Table 7-2, Table 7-3, and Table 7-4 list the weighting factors received in response to e-mails sent, for each of the three groups of countries. The average and standard deviation of the factors have also been included. The average is used for the calculation of the TSI. The respondents' ages fall in the range of 25–45 (average being close to 33). They are representative of the generation which will strongly influence (and be influenced by) changes happening in the world in the next two decades. Their prioritisation thereby can be considered to be quite realistic for the near future.

Weighting factor	Values from responses (in %), separated by commas	Weighting factor	Values from responses (in %), separated by commas
W_E	25	w_{S4}	20
W_{EN}	25	w_{S5}	10
W_S	20	w_{S6}	10
W_I	30	w_{I1}	10
w_{E1}	60	w_{I2}	30
w_{E2}	20	w_{I3}	40
w_{E3}	10	w_{I4}	20
w_{E4}	10	w_{EN1}	30
w_{S1}	20	w_{EN2}	30
w_{S2}	25	w_{EN3}	20
w_{S3}	15	w_{EN4}	20

Table 7-2: Weighting factors for Low Income countries

Weighting factor	Values from responses (in %), separated by commas	Average	Standard deviation
W_E	60, 20, 30, 20, 40, 30, 25, 25, 25, 20	29.5	12.3
W_{EN}	5, 20, 30, 40, 10, 20, 25, 15, 20, 30	21.5	10.3
W_S	30, 40, 30, 10, 40, 35, 25, 35, 35, 25	30.5	8.9
W_I	5, 20, 10, 30, 10, 15, 25, 25, 20, 25,	18.5	8.1
w_{E1}	25, 50, 20, 20, 20, 50, 40, 30, 25, 25	30.5	11.8
w_{E2}	25, 15, 30, 20, 20, 30, 20, 25, 30, 30	23.5	5.3
w_{E3}	25, 15, 30, 30, 40, 10, 20, 15, 20, 20	23.5	9.1
w_{E4}	25, 20, 20, 30, 20, 10, 20, 30, 25, 25	22.5	5.9
w_{S1}	20, 20, 20, 10, 45, 20, 60, 10, 20, 10	23.5	16.3
w_{S2}	15, 25, 20, 20, 5, 10, 5, 10, 15, 25	15	7.45
w_{S3}	20, 5, 20, 30, 20, 20, 20, 20, 25, 15	20	7.1
w_{S4}	15, 5, 20, 30, 20, 20, 5, 20, 20, 20	17	7.5
w_{S5}	15, 15, 10, 10,5, 15, 5, 20, 10, 15	12	4.8
w_{S6}	15, 20, 10, 10, 5, 15, 5, 20, 10, 15	12.5	5.4
w_{I1}	25, 30, 50, 20, 40, 40, 60, 35, 30, 30	36	9
w_{I2}	25, 50, 30, 40, 40, 25, 20, 30, 60, 40	36	12.9
w_{I3}	25, 10, 10, 20, 10, 15, 5, 15, 5, 10	13	5.8
w_{I4}	25, 10, 10, 20, 10, 20, 5, 20, 5, 20	15	6.6
w_{EN1}	25, 20, 0, 30, 10, 20, 30, 25, 15, 15	19	9.3
w_{EN2}	25, 20, 50, 40, 40, 40, 50, 30, 40, 40	37.5	9.7
w_{EN3}	25, 10, 20, 15, 40, 25, 10, 15, 30, 5	19.5	10.6
w_{EN4}	25, 50, 30, 15, 10, 15, 10, 30, 15, 40	24	13.4

Table 7-3: Weighting factors for Low-Middle Income countries

Weighting factor	Values from responses (in %), separated by commas	Average	Standard deviation
W_E	30, 20, 20, 30	25	5.8
W_{EN}	20, 30, 40, 30	30	8.2
W_S	20, 15, 20, 20	18.75	2.5
W_I	30, 35, 20, 20	26.25	7.5
w_{E1}	25, 30, 20, 10	21.25	8.5
w_{E2}	25, 15, 30, 20	22.50	6.4
w_{E3}	25, 15, 30, 40	27.50	10.4
w_{E4}	25, 40, 20, 30	28.75	8.5
w_{S1}	20, 25, 10, 25	20	7.1
w_{S2}	10, 20, 20, 20	17.50	5
w_{S3}	20, 10, 35, 10	18.75	11.8
w_{S4}	20, 20, 15, 25	20	4.1
w_{S5}	15, 15, 10, 10	12.50	2.5
w_{S6}	15, 10, 10, 10	11.25	2.9
w_{I1}	30, 40, 30, 30	32.50	5
w_{I2}	30, 10, 40, 40	30	14.1
w_{I3}	20, 25, 20, 15	20	4.1
w_{I4}	20, 25, 10, 15	17.50	6.4
w_{EN1}	30, 15, 20, 20	22.25	6.3
w_{EN2}	25, 35, 20, 40	30	9.1
w_{EN3}	20, 10, 10, 20	15	5.7
w_{EN4}	25, 40, 50, 20	33.75	13.7

Table 7-4: Weighting factors for High-Middle Income countries

On average, for the Low-Middle Income group of countries (for which there were many responses), respondents value the socio-economic over the environmental and infrastructural. The primary sector gets a greater weighting vis-à-vis the secondary, tertiary and the trade balance; the last three being weighted almost equal to each other. Renewable energy (as percentage of total electricity generation), the percentage of paved roads and the per-capita total electricity generation itself are more important indicators. Access to water supply, quite obviously, gets 3 percentage points more than access to sanitation; for the latter ideally ought to follow the former. For the High-Middle Income group (all respondents were incidentally of Chinese provenance), the environment is weighted over the social, economic and infrastructural. Within the environmental sustainability criterion, the 'percentage of terrestrial and marine protected areas' is weighted the highest. The export/import ratio and the growth in the tertiary sector are prioritised over the growth in the primary and secondary sector, within the economic sustainability criterion.

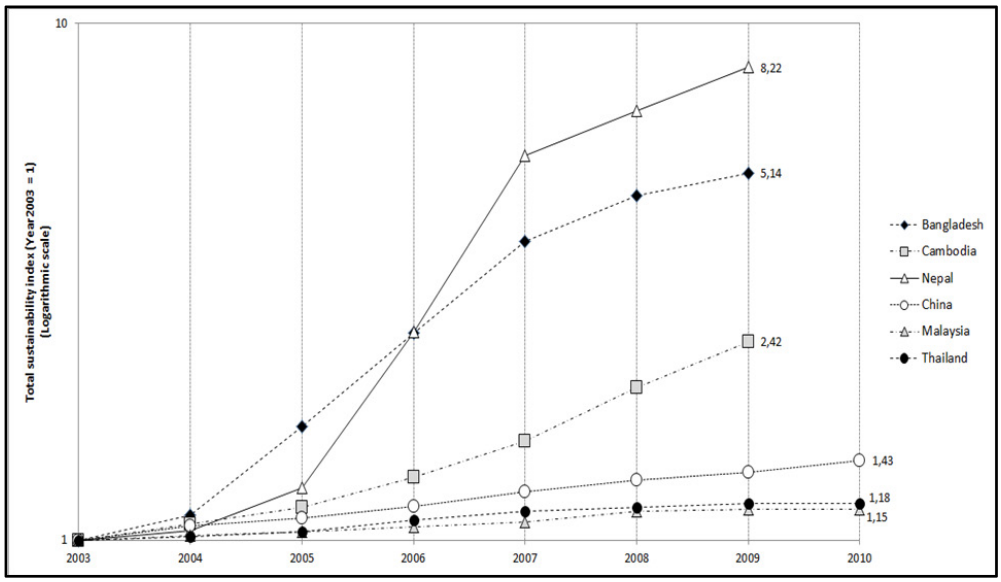


Figure 7-2: TSI for the Low Income and High-Middle Income countries considered in this study (with respect to year-2003, for each country)

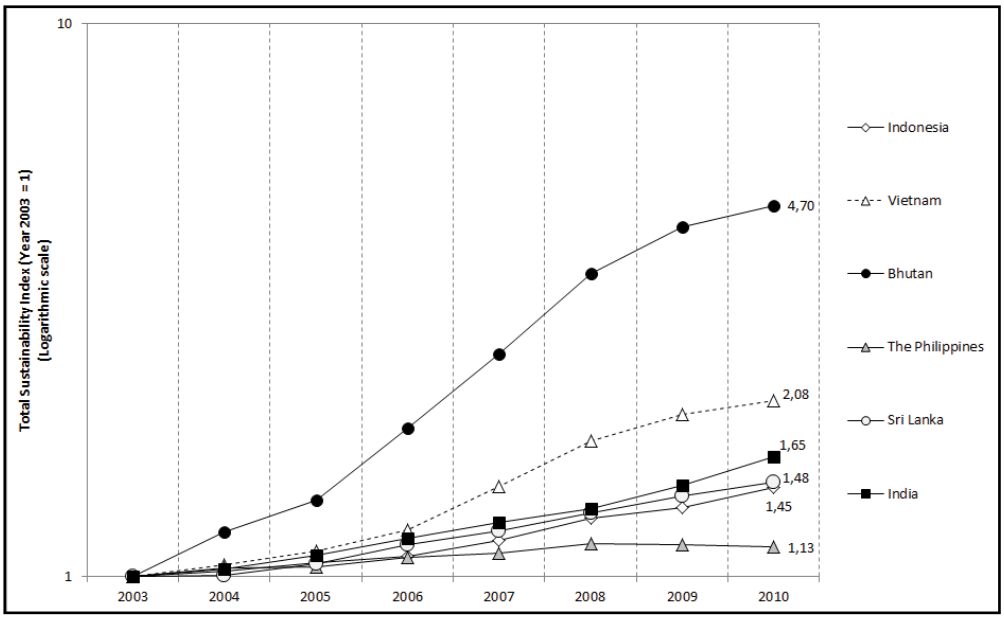


Figure 7-3: TSI for the Low-Middle Income countries considered in this study (with respect to year-2003, for each country)

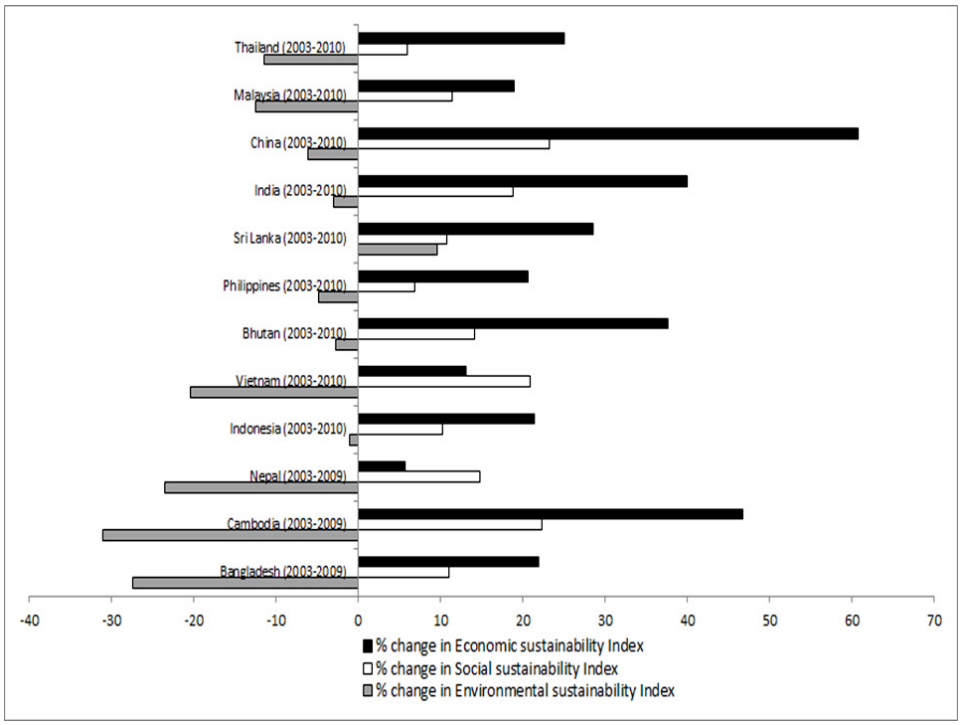


Figure 7-4: Changes in the sustainability indices for three of the four criteria, for all the 12 countries, over the specified time period for each of them

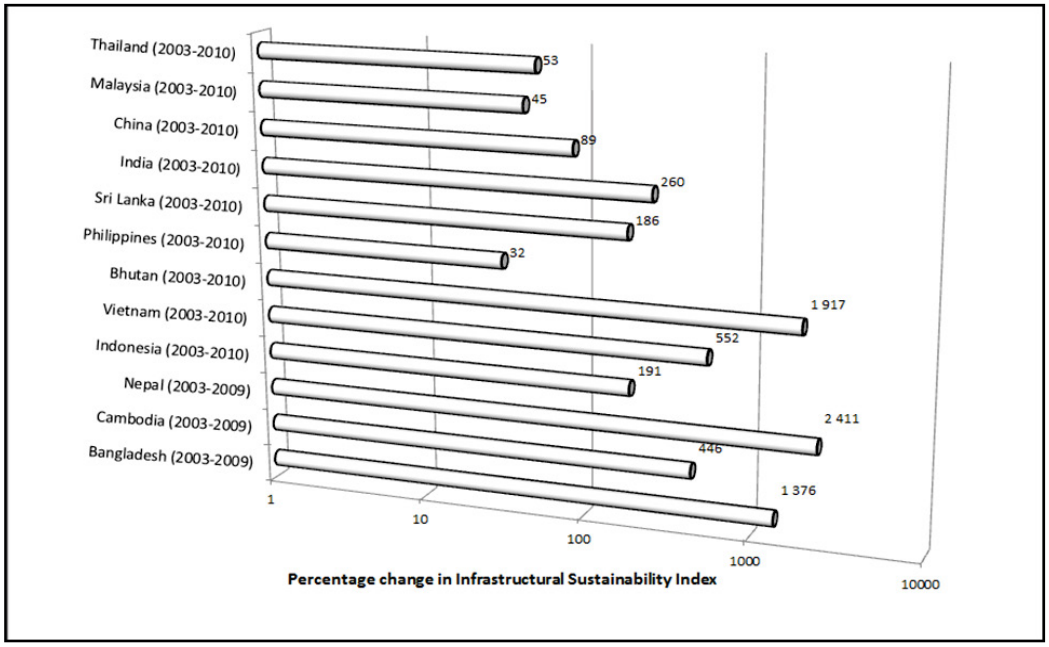


Figure 7-5: Changes in the Infrastructural Sustainability Index for all the 12 countries, over the specified time period for each of them

Figure 7-2 and Figure 7-3: depict the trends in the TSI for each of the twelve countries. For each country, the values for years 2004 and later, are normalised with respect to the state of each country in year-2003. As mentioned before in the paper, care should be exercised in interpreting the graphs. They are not intended for comparing the states of different countries at any point in time; but rather the relative sustainability performance over time, with respect to year-2003. The TSI of Nepal increased by 822% over the seven-year period 2003–2009. During the same period, Cambodia and Bangladesh registered increases of 242% and 514% respectively. These increases were largely owing to the rapid rise in the value of the infrastructural indicator – Mobile subscriptions per 100 people – over the said period (refer Figure 7-5). The High-Middle Income countries registered modest increases in TSI of 43% (China; at a CAGR of close to 5%), 18% (Thailand; at a Compounded Annual Growth Rate (CAGR) of 2.4%) and 15% (Malaysia; at a CAGR of 1.9%). Among the Low-Middle Income countries, Bhutan's TSI grew fastest and stood at 4.7 in 2010 (with respect to 1 in year-2003). The others recorded increases in the range of 13% to 108%. It must be pointed out at this juncture that the TSI for the Philippines rose from year-2003 and peaked in year-2008 before dropping down slightly to its relative value of 1.13 in 2010.

Figure 7-4 depicts the changes in the social, economic and environmental indices for the 12 countries, while Figure 7-5 does the same for the infrastructural. Among the Low Income countries, over the period 2003–2009, the changes in the Economic, Environmental and Social Sustainability Indices were the greatest for Cambodia at 46.6%, -31% and 22.4% respectively; while Nepal registered the highest increase in the Infrastructural Sustainability Index (2411%). Bangladesh. Nepal and Cambodia – countries in the lower stratum of the developing world, register relatively faster increases in their respective TSIs vis-à-vis those in the Low-Middle Income and High-Middle Income groups. This is courtesy the harnessing of the 'low-hanging fruit' in this case – especially the rapid growth in the value of the indicator 'mobile subscriptions per 100 people'. Of course, results obtained in this paper are sensitive to (and dependent on) the choice of indicators as well as the weighting factors.

As far as the Low-Middle Income countries are concerned, over the period 2003-2010, the corresponding countries and the percentages of increase were India (40%), Vietnam (-20.5%) Vietnam again (21%) and Bhutan (1917%). For the three High-Middle Income countries in the fray, over the time period 2003–2010, China was the leader of the pack in all categories expect one. While the Environmental Sustainability Index dropped for all three countries, Malaysia recorded the highest drop (-11.9%). Among all the 12 countries, it was only Sri Lanka whose Environmental Sustainability Index improved over the 8-year period, by 9.55%.

It is seen that a drop in the Environmental Sustainability Index (or a relatively slow growth in the same), is a price to be paid to effect improvements in the other three indices. This index thus tends to retard the rise in the TSI. A growth in the Gross Domestic Product per-capita is most welcome, but what it more important is what it entails for social sustainability, and at what cost to the environment such growth happens.

7.5 Conclusions and recommendations

Ideally, different countries would adopt different sets of indicators. Weighting factors also may usually not be the same for different countries. They would also not be constant over time. Such factors are usually aligned closely with the realities-on-the-ground and policies formulated by governing bodies. Thus, it follows that they need to be re-examined from time to time – both the indicators themselves and their weighting factors. Re-evaluation is necessary as some indicators may cease to be of importance after some time (and may have to be excluded or down-weighted). New challenges would then call for reformulation in the policies and thereby the definition of new indicators.

Weighting factors are subjective but as mentioned in the Literature Review section, *'at least they are explicit. Otherwise, priorities are set implicitly, and sometimes inadvertently, by the push and pull of politics. Combining these dimensions into a single score by which countries can be compared, also concentrates minds.'* The comparison referred to in the previous sentence is not one among the 'states' of countries at any given period of time, but rather among the 'paths' from the starting point on their respective curves of sustainable development. Comparing the 'states' is meaningless as the starting points are not the same, and some countries are endowed with geographical and/or natural and/or historical advantages – more so than the others.

Some countries measure and record data systematically and make them available to the World Bank. Many do not. Further, apart from the data gaps, there is also some uncertainty as regards the accuracy of the data recorded (or measured and submitted to the recording authority – the World Bank in this case). As reported in The Economist (2013C, p. 47), if activity in the informal sector and rural areas were properly measured in India, its GDP would look bigger and more stable. The new head of the Reserve Bank of India – Raghuram Rajan – is quoted in the same news item, as saying that the GDP could be revised by as much as 10%.

The applicability of this method is highly dependent on the availability of reliable and reasonably-accurate data; also comprehensive to boot. Governments may be encouraged to invest more resources in data-gathering in this era of 'Big Data', where robust decisions can be taken by crunching numbers using models like the one developed in this paper.

7.6 Acknowledgements

Thanks to *Gang Liu, Citra Prasetyo, Vera Gunawan, Bhawna Singh, Netra Timalsina, Sunand Sreeramachandran, Kamna Sachdeva, Ushanth Navaratnam, Bertha Maya Sopha, Gema Sakti Raspati, Xinxin Wang, Chao Fu and Juan Tan, for responding promptly with their opinions on the weighting factors.*

7.7 Appendices

Appendix I

Low income	Lower middle income	Upper middle income
Bangladesh, Cambodia, Nepal	Bhutan, Indonesia, The Philippines, Vietnam, Sri Lanka, India	China, Malaysia, Thailand

Table 7-5: World Bank classification of the 19 Asian countries considered (July 2012)

Appendix II

Explanations of the fields selected from the World Bank database, for direct use as indicators or as primary data for derived indicators.

ECONOMIC

- ***Imports of goods and services (% of GDP):*** Imports of goods and services represent the value of all goods and other market services received from the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments. Data are in constant 2000 U.S. dollars.
- ***Trade (% of GDP):*** Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product.
- ***Agriculture, value added (% of GDP):*** Agriculture includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources.

- ***Industry, value added (% of GDP):*** Industry corresponds to ISIC divisions 10–45 and includes manufacturing (ISIC divisions 15–37). It comprises value added in mining, manufacturing (also reported as a separate subgroup), construction, electricity, water, and gas. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources.
- ***Services, value added (% of GDP):*** Services correspond to ISIC divisions 50–99 and they include value added in wholesale and retail trade (including hotels and restaurants), transport, and government, financial, professional, and personal services such as education, health care, and real estate services. Also included are imputed bank service charges, import duties, and any statistical discrepancies noted by national compilers as well as discrepancies arising from rescaling
- ***GDP (constant USD):*** GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2000 U.S. dollars. Dollar figures for GDP are converted from domestic currencies using 2000 official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used.
- ***GDP per capita (constant USD):*** GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2005 U.S. dollars.

SOCIAL

- ***Household final consumption expenditure, etc.:*** Household final consumption expenditure (formerly private consumption) is the market value of all goods and services, including durable products (such as cars, washing machines, and home computers), purchased by households. It excludes purchases of dwellings but includes imputed rent for owner-occupied dwellings. It also includes payments and fees to governments to obtain permits and licenses. Here, household consumption expenditure includes the expenditures of nonprofit institutions serving households, even when reported separately by the country. This item also includes any statistical discrepancy in the use of resources relative to the supply of resources. Data are in constant 2005 U.S. dollars.

- ***Literacy rate, adult total:*** Adult (15+) literacy rate (%). Total is the percentage of the population age 15 and above who can, with understanding, read and write a short, simple statement on their everyday life. Generally, 'literacy' also encompasses 'numeracy', the ability to make simple arithmetic calculations. This indicator is calculated by dividing the number of literates aged 15 years and over by the corresponding age group population and multiplying the result by 100.
- ***Improved water source (% population with access):*** Access to an improved water source refers to the percentage of the population with reasonable access to an adequate amount of water from an improved source, such as a household connection, public standpipe, borehole, protected well or spring, and rainwater collection. Unimproved sources include vendors, tanker trucks, and unprotected wells and springs. Reasonable access is defined as the availability of at least 20 litres a person a day from a source within one kilometre of the dwelling.
- ***Improved sanitation facilities (% population with access):*** Access to improved sanitation facilities refers to the percentage of the population with at least adequate access to excreta disposal facilities that can effectively prevent human, animal, and insect contact with excreta. Improved facilities range from simple but protected pit latrines to flush toilets with a sewerage connection. To be effective, facilities must be correctly constructed and properly maintained.
- ***Life expectancy at birth (years):*** Life expectancy at birth indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life.

ENVIRONMENTAL

- ***Fertiliser consumption (kg/hectare of arable land):*** Fertilizer consumption measures the quantity of plant nutrients used per unit of arable land. Fertilizer products cover nitrogenous, potash, and phosphate fertilizers (including ground rock phosphate). Traditional nutrients – animal and plant manures – are not included. For the purpose of data dissemination, FAO has adopted the concept of a calendar year (January to December). Some countries compile fertilizer data on a calendar year basis, while others are on a split-year basis. Arable land includes land defined by the FAO as land under temporary crops (double-cropped areas are counted once), temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land temporarily fallow. Land abandoned as a result of shifting cultivation is excluded.
- ***Electricity production from renewable sources (kWh):*** Electricity production from renewable sources includes hydropower, geothermal, solar, tides, wind, biomass, and biofuels.
- ***Carbon dioxide emissions (metric tons per capita):*** Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring.

- ***Terrestrial and marine protected areas (% of total territorial area):*** Terrestrial protected areas are totally or partially protected areas of at least 1,000 hectares that are designated by national authorities as scientific reserves with limited public access, national parks, natural monuments, nature reserves or wildlife sanctuaries, protected landscapes, and areas managed mainly for sustainable use. Marine protected areas are areas of intertidal or sub-tidal terrain – and overlying water and associated flora and fauna and historical and cultural features – that have been reserved by law or other effective means to protect part or all of the enclosed environment. Sites protected under local or provincial law are excluded.

INFRASTRUCTURAL

- ***Electricity production (kWh):*** Electricity production is measured at the terminals of all alternator sets in a station. In addition to hydropower, coal, oil, gas, and nuclear power generation, it covers generation by geothermal, solar, wind, and tide and wave energy, as well as that from combustible renewables and waste. Production includes the output of electricity plants that are designed to produce electricity only as well as that of combined heat and power plants.
- ***Roads, paved (% of total roads):*** Paved roads are those surfaced with crushed stone (macadam) and hydrocarbon binder or bituminized agents, with concrete, or with cobblestones, as a percentage of all the country's roads, measured in length.

- ***Mobile cellular subscriptions (per 100 people):*** Mobile cellular telephone subscriptions are subscriptions to a public mobile telephone service using cellular technology, which provide access to the public switched telephone network. Post-paid and prepaid subscriptions are included.
- ***Telephone lines (per 100 people):*** Telephone lines are fixed telephone lines that connect a subscriber's terminal equipment to the public switched telephone network and that have a port on a telephone exchange. Integrated services digital network channels and fixed wireless subscribers are included.

Appendix III

Name	Age	Country of origin	Years resident in country of origin	Gender
Bertha Maya Sopha	36	Indonesia	25	Female
Bhawna Singh	32	India	24	Female
Chao Fu	30	China	25	Male
Citra Prasetyo	26	Indonesia	22	Female
G Venkatesh (author)	41	India	32	Male
Gang Liu	31	China	26	Male
Gema Sakti Raspati	36	Indonesia	28	Male
Juan Tan	30	China	25	Female
Kamna Sachdeva	34	India	34	Female
Netra Timalsina	35	Nepal	30	Male
Sunand Sreeramachandran	33	India	22	Male
Ushanth Navaratnam	29	Sri Lanka	26	Male
Vera Gunawan	40	Indonesia	25	Female
Xinxin Wang	31	China	26	Female
	Average age: **33**		Average: **26**	

Table 7-6: Respondents who opined about weighting factors

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7.9 Exercise VII

1. Try to perform a similar analysis for one of the following groups of countries. The Internet could be the data source, in the absence of other alternate sources.
    a) The EU-group of countries
    b) The Mercosur group of countries
    c) The Southern African Development Corporation group of countries

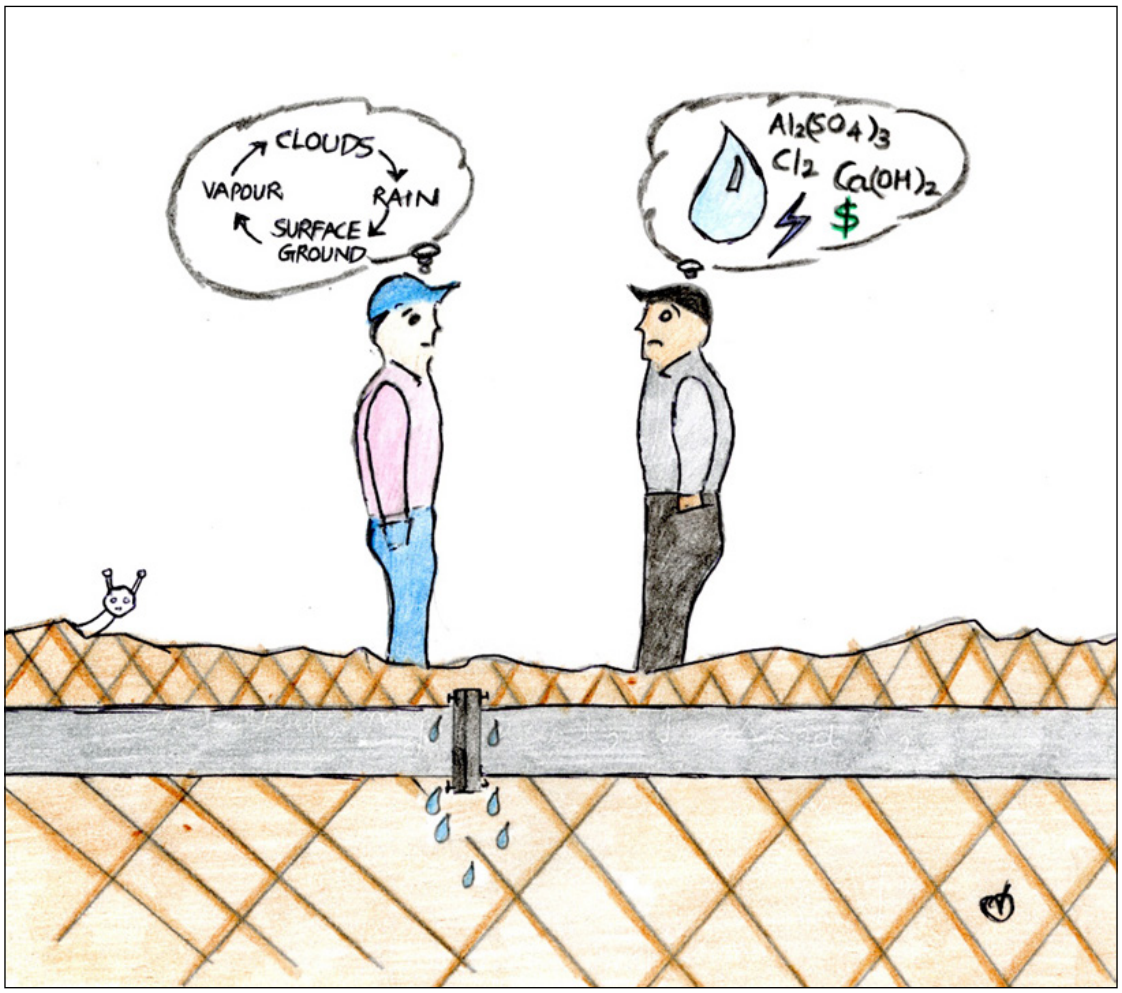
    Feel free to redefine the criteria and indicators if you feel that would be necessary. You would have to reach out to your network of friends and acquaintances in the group you select, for the weighting factors.

2. Do you agree with the following statements made in the article above?
    a) Weighting factors ought to change over time
    b) Comparisons among different countries are not warranted

    If you do not, explain why?

8 En passant – some other sustainability analyses

Learning objectives: To motivate students to access and read published journal papers, and also to give an idea of how sustainability analyses can be tailor-made to different cases[34], depending on what the objective/s is/are. Chapter 6 presented a paper on total sustainability as applicable to countries on the whole, while in this chapter, students will learn how sustainability analyses can be carried out on sub-system-level/project level.



In Chapter 7, you have noted the addition of the dimension 'Infrastructural' to the conventional trio. Also mentioned in Chapter 6 was the fact that in Venkatesh (2011)[35], the dimension 'Functional' was added in the context of sustainability of the urban water system. In Alegre (2012)[36], again with respect to the urban water system, 'Assets' have been suggested as a dimension, in addition to the conventional trio and 'Governance'. In Venkatesh et al (2014)[37], which presents the Dynamic Metabolism Model applied to sustainability analysis of performance of the Oslo water utility (Norway), 'Functional' and 'Physical' make up the quintet of dimensions defined. It is easy to follow here that 'Infrastructural', 'Physical' and 'Assets' are fairly similar to each other, if not exactly the same. The indicators *per se* however, may not be defined in the same manner.

As was pointed out in Chapter 6, the definition of the dimensions (or criteria) and the selection of the indicators belonging to these criteria is the analyst's prerogative. Here, the author wishes to refer readers to a published paper[38] in which sustainability analysis entailed just two criteria – the economic and environmental, and another in which what would ideally be classified as 'Functional' served as a proxy for social sustainability[39]. The focus of these papers was on sub-systems of the urban water system, and the objective was to compare the sustainabilities of different approaches (to biogas handling in the first, and to water treatment in the second).

8.1 The biogas study

This paper[38] outlines a methodology for a systematic enviro-economic analysis of realistic and realizable options for recovering and utilising energy from biogas produced in sewage sludge digesters in wastewater treatment plants (WWTPs). Heat, electricity and transport fuel can be produced from biogas, consumed in-plant or even sold to external end-users. Global warming is considered in the paper, as the environmental impact of concern, but a caveat is in place to indicate the necessity of avoiding problem shifting by factoring in other non-negligible environmental impact categories as well. The case studied here is the Bekkelaget WWTP in Oslo (Norway). Five different options for handling biogas are considered, in addition to the *status quo* – the business-as-usual in year-2012, and a baseline case, where it is assumed that all biogas generated is flared completely and not utilised for energy recovery of any kind. Seven different cost scenarios – for electricity, natural gas, wood pellets, bio-methane and diesel – are constructed. This gives a total of 49 combinations, for each of which the net costs and net environmental impacts (global warming, eutrophication and acidification) are determined for the 10-year period of 2012–2021. The changes (in percentages) with respect to the corresponding values for the baseline case, are recorded; suitable weighting factors are considered after interaction with experts and personnel associated with the plant, and the options are evaluated using this so-called 'double-bottom-line approach'..

8.2 The water treatment paper[39]

This paper[39] begins on the premise that there could be many options a water treatment plant (WTP) can select from, if the end-goal is an improvement in the quality of the treated water. A triple- bottom-line approach has then adopted to compare a set of seven possible approaches towards meeting the specified end-goal at the Stangasen WTP in the town of Oppegard in south-eastern Norway. These seven include the use of five different dosages of granulated aluminium sulphate as coagulant, liquid aluminium sulphate (48%) and liquid ferric chloride (40%). Using the set of weighting factors obtained from experts, the paper has determined that increasing the dosage of granulated aluminium sulphate by 20% over the current one would be the most sustainable option from a triple-bottom-line point of view.

After reading through the paper, one would learn to question the logic of investing more in making water which is already quite pure, even purer and safer in a more sustainable way. Of course, deciding upon weighting factors, the paper observes, will continue to be a subjective process open to questioning, but that is a 'necessary evil' if one may dub it so, to clear the way forward for an integration of the social, economic and environmental considerations into decision-making. The political dimension of sustainability can often trump the social, economic and environmental aspects. The political dimension is akin to governance discussed in Chapter 5, but in cases like the one discussed in this paper, officials may start off by setting some fixed goals, like water quality targets for instance. Then, one would need to discard all possible solutions which do not satisfy these imposed requirements. The question of sustainability then becomes meaningful only when one attempts to compare different possibilities of fulfilling these requirements. Further, if there are lock-ins of some kind, and a certain amount of 'political inertia' to overhauling (and creative destruction), an alternative which is proven to be holistically more sustainable than the others may also be sidelined.

8.3 Dynamic Metabolism Model

In the paper[37] discussing the application of the Dynamic Metabolism Model to the sustainability assessment of the water utility in Oslo, Norway, five dimensions of sustainability have been defined – Physical and Functional, in addition to the triple-bottom-line. Interventions which the water utility wishes to implement for the future are compared among themselves, by calculating the values of 30-odd indicators (per-capita & per-unit-volume-water-treated-annually) grouped under these five dimensions over a time-period of close to 40 years. It is a known fact that urban water services are challenged from many perspectives and different stakeholders demand performance improvements along economic, social and environmental dimensions of sustainability.

The paper has adopted a holistic systems perspective to the analysis of metabolism and environmental impacts of resource flows in the water utility of Oslo, in order to offer a tool which could be used by utilities in general to understand how to get onto the path of sustainable development, while gearing up for the challenges of the future.

The model, in the form it has been used, for this paper, stops short of calculating a TSI. The officials at the water utility in Oslo were not in a position to come up with weighting factors for the indicators. The authors were of the view that weighting being a subjective process, the best way to proceed would be to obtain the weightages from the water utility itself. This not being possible, the paper has not been able to arrive at a weighted, aggregated TSI for each intervention. This simply implies that it would not be possible with just a bunch of indicator values to rank the interventions on the basis of holistic (or total) sustainability. This is what the paper would ideally have liked to end with, but for the reason stated above, that was not to be.

8.4 Last word…more papers

En passant, the author would like to urge students to look for more published journal papers having sustainability assessment as the theme, evaluate them critically and improve their understanding of sustainability and sustainable development, how it has been/is being/must be factored into decision-making at different levels – project, firm/enterprise, city/town, region/province, country/continent/world.

8.5 Exercise VIII

1. Read the following papers (accessible on ResearchGate):
   a) Venkatesh G. and Elmi R.A. (2013) Economic-environmental analysis of handling biogas from sewage sludge digesters in wastewater treatment plants for energy recovery: Case study of Bekkelaget Wastewater Treatment Plant in Oslo (Norway). Energy, 58(10): 220–235.
   b) G. Venkatesh, Kamal Azrague, Bjørnar Eikebrokk, Stig Bell (2015). Triple bottom line assessment of raw water treatment: Application to the municipality of Oppegård in south-eastern Norway. *Environmental Technology*, 36(15): 1954–1965.

Write your own critiques for both of them (600–800 words each). You would have read short descriptions about these papers in the chapter already. However, you need not be influenced by those when you critique.

9 Epilogue

'It is not the differences among people that is a concern, but the indifference'

– Anonymous (read by the author in the Bombay Times,
The Times of India, 11th April 2015)

A survey[40] was recently conducted by the author (as part of the Higher Education, Research and Development / Energy project in Europe, of which the Faculties of Architecture of the Norwegian University of Science and Technology in Trondheim, and the University of Sarajevo in Bosnia were partners) to glean the prospects of, and the inclination towards incorporating the paradigm of sustainability (with a focus on energy efficiency in the case of this particular project) in university-pedagogy. The individuals who were contacted with the survey questionnaire (by e-mail), were professors, associate professors, adjunct professors and lecturers in universities around the world, a sizable percentage of them obviously being from the two partner universities referred to. The 15 questions sent encompassed *inter alia* pedagogical aspects, outputs / results, collaborative approaches, integration with other disciplines and other sectors outside academics. Figure 9-1 lists the questions sent and Figure 9-2 presents graphically the responses received.

Over 95% of the respondents said that they have been and will continue to strive to impress upon their students the imperativeness of converting knowledge into action. Most of the respondents said that they were aware of the need for life-cycle thinking and believed it was indispensable if sustainability had to be properly understood. It was good to see that a majority of them always introduced life-cycle thinking to students in their lectures. In architecture especially, life-cycle thinking is very critical, if what is designed and implemented has to be sustainable over a long period of time. Life-cycle thinking would motivate one to think in terms of reducing life-cycle costs, by risking higher capital investments and managing to reduce the long-term maintenance expenses. How something designed and built today would 'behave' in the years to come, in the face of rapidly-fluctuating external factors in a highly-globalised world, is what one is taught to think about, through 'life-cycle thinking'.

Interestingly, there were as many respondents who were aware of the triple-bottom-line approach and who taught it to their students, as there were who either had not heard about it, or felt that it was not relevant at all to the subject/s they were teaching. The authors contended that it was possible to introduce the concept of holism in most subjects, by being a little creative about the pedagogical approach one adopts. Holism essentially is the overarching Truth that 'everything is somehow related to almost everything else.'

Serial number	Question with multiple choices	Enter your response in this column
1	How many years have you been a University teacher/lecturer/professor?	
	A Less than 1	
	B Between 1 and 3	
	C Greater than 3	
2	Is sustainability and/or energy efficiency in the built environment a component of the subject/s you teach?	
	A Yes, very much so	
	B No, not at the moment, but will include in future	
	C No, there is no scope for these	
3	Would you ever tell students that with technology everything is possible, when it comes to optimising energy use, improving energy efficiency and achieving sustainability in the built environment?	
	A Yes, I always teach that	
	B No, never	
	C Not really sure	
4	Have you introduced the triple-bottom-line approach to sustainability in energy-related issues to your students?	
	A Yes, I have done that	
	B No, not yet, but would like to	
	C No, am not aware of it or its applicability to my subject/s	
5	Would you teach students to differentiate between 'improving energy efficiency' and 'reducing absolute energy consumption'?	
	A Yes, I would	
	B Not sure if there is a difference between these two terms	
6	When you teach (or will teach) sustainability, do you (or will you) encourage students to adopt life-cycle thinking while planning, designing or solving problems?	
	A Always	
	B Often	
	C Never; do not plan to	
	D Never do currently, will try to incorporate	
7	Do you think you are successful in enabling students to think laterally and creatively and be motivated to convert knowledge to action, theory to practice?	
	A No, but would like to be	
	B Yes, more often than not	
	C Sometimes, depends on the motivation levels of the students	
8	Do you think that Joint Masters Courses with Universities in different parts of the world help students to get holistic and realistic views of issues related to energy efficiency improvements and sustainability?	
	A Yes, this is true and I am in favour of more Joint Masters Programmes	
	B Yes, but one must not stress too much on this	
	C Not necessarily; often it is a wasted effort	

9	Would you introduce your students to lecturers from other disciplines - applied sociology, applied law, applied psychology etc. - in order to impress upon them that sustainability includes a lot more than just science and technology, and this must be accepted?	
	A No, will not try this	
	B Yes, most certainly; have been doing it	
	C I am a bit undecided on this	
10	Does having a class with students from different parts of the world make it difficult to teach sustainability and energy efficiency?	
	A No, not at all; it makes it challenging but more rewarding	
	B Yes, at times, owing to cultural and experiential differences	
	C Have never really thought about this / Have not taught international students	
11	Do students in your class have the freedom to express their points of view, discuss and debate, with respect to sustainability and energy efficiency aspects and the conflicts which often arise when quality of life is factored in?	
	A No, it is a cultural thing; they do not participate actiively	
	B Yes, they have the freedom, but I am not able to build up an interactive session	
	C Yes, they have the freedom, use it, and every class throws up new ideas	
12	How successful have you been in motivating students to convert their project reports and Masters theses (which may be very good and relevant case studies) into journal publications or publications of other types, to add to the volume of publicly-available knowledge on sustainability and energy efficiency in the built environment?	
	A Very much so; I make it a point to always explore such possibilities	
	B Have not thought about this; but a good idea I would like to pursue	
	C Do not think this is really necessary when there are PhDs and PostDoc doing this already	
13	Is language a constraint in communicating knowledge about sustainability and energy efficiency? Is there sometimes a case of 'lost in translation' when it becomes difficult to convey to students speaking other languages, the real meaning and implication of terms and concepts related to these subjects?	
	A Yes, sometimes	
	B No, I do not think so	
14	In your opinion, how important is it to build bridges between the academia on the one hand, and the government, industry and society on the other, when dealing with issues like sustainability in the built environment? Give your answer on a scale of 10 (1= very important & 10=not important at all)	
15	A Masters Degree in Energy Efficiency! If such a course / module would come up, how do you think you could contribute to it? Here we are focusing on applications extending to the built environment (utilities, transport, buildings) and industry? (Can you answer this in 1-2 sentence/s?	

Figure 9-1: The questionnaire

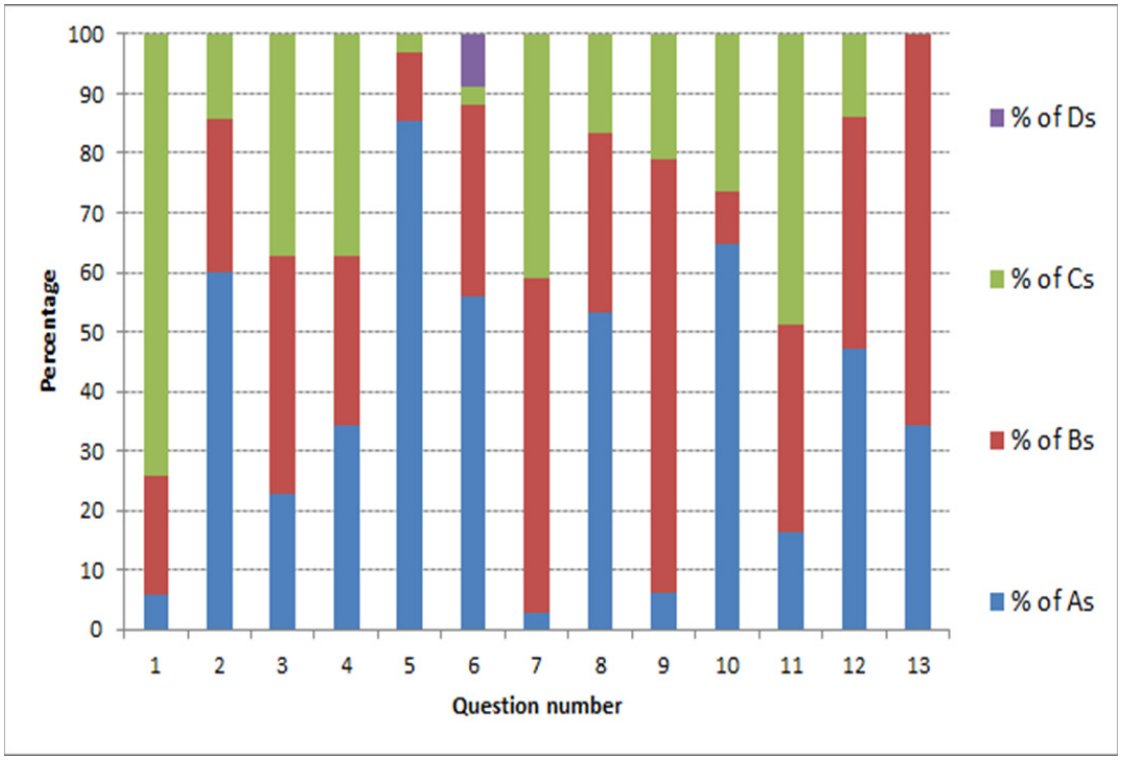


Figure 9-2: Responses to questions, graphically represented

Technology is often looked upon as an elixir, as a panacea, as a cure-all. But it is not so, and that need not be proven. Human behaviour and the way humans understand and use technology is what matters. The Internet is a marvelous invention but it has its dark underbelly, as we all know and agree. Hence, it was really very surprising (and alarming) that quite a few respondents said that they would teach students that technology is a 'cure-all'! If sustainability is to be taught, it would be a folly to start off with the premise that technology can solve all our problems. It is here that there is a distinct need to convince teachers that this is not the case, and it would not be a good idea to drill this into the minds of students. These students are the ones who will go out into the world in the near future and tackle real-life problems and challenges, and the education imparted to the ought to help them to succeed in this. Over 50% of the respondents considered the bridge-building between academics on the one hand and the government, society and industry on the other (integration, if we could call it so) as something which could not be ignored, especially when it came to teaching about and practicing sustainability. Sustainability research and pedagogy cannot be merely about ivory-tower concepts and armchair ideas. University education has evolved from being an island to a 'contiguous landmass' linked to society, industry and government and working in close collaboration with these three, to solve practical problems which the world is facing at the moment. Education nowadays must perforce be an enabler of sustainable development out in the world. Paradigms like sustainability and sustainable development are multi-faceted and students from different nationalities, cultures and backgrounds have different notions about these. The pedagogue is expected to invite criticism, be willing to accept different points of view, and while trying to understand the reason for the differences, be able to ultimately convince students about the imperativeness of focusing on sustainable development. About 50% of the respondents claimed that they gave their students the freedom to voice their opinions and that every class threw up new ideas which benefit all the students. Students from different parts of the world – developed, developing and transition economies – bring with them a lot of practical knowledge gained from experience. Sustainability is never achievable by adopting a one-size-fits-all approach. Sustainable development makes sense when the whole world benefits from the process. And to make this possible, one needs to tailor-make solutions. Preaching environmental sustainability as a must-pursue to a class which has some students from the developing world (say Africa), is a bit unfair, as those students have every right to wonder why they should be deprived of the right to focus on economic growth first. Energy efficiency (even advising on cutting down absolute energy consumption) may still be fine when one is addressing a class full of students from the developed world – USA, Japan and Western Europe for instance. However, the African students may first want to know how to augment their respective national energy productions.

About 60% of the respondents said that sustainability was very much a part of the syllabus of the subjects they taught. Close to one-fourth of those who responded to this question, agreed that it could be made a part of the syllabus in the future (though not currently). A relative minority turned it down as being beyond the scope of the subjects they teach. It would be possible of course to identify creative approaches to incorporating at least sustainability into their respective syllabi.

Sustainability is very much an in-thing these days, and universities ought to gear up to keep up with the demands of changing times, and incorporate modern and relevant concepts into the courses they offer and the subjects they teach. Teachers can keep making efforts consistently to think laterally and modify their approaches. Closer collaborations with other universities, government agencies, society and industry are very much necessary. There has been a paradigm shift in this regard, and that needs to be respected. The Western World can contribute to development in education in the transition economies and developing countries courtesy Joint Masters Programmes and more meaningful research activities.

Endnotes

1. Based in Norway at the time of writing this e-book.
2. Venkatesh G. Sisyphean struggle or Pyrrhic victory. *Problems of Sustainable Development (Problemy Ekorozwoju)*, 9(2): 73–77, 2014.
3. Venkatesh G. The penny drops. Financial Chronicle, 17th March 2015, Vol 7, Issue 283, p. 13. Accessible at http://www.mydigitalfc.com/knowledge/penny-drops-463.
4. Venkatesh G. Sustainable development as a single measure: Case study of some developing Asian countries. *Problemy Ekorozwoju*, 10(2):xx-xx, 2015.
5. Kallio T.J., Nordberg P. and Ahonen A. Rationalising Sustainable Development – a critical treatise', *Sustainable Development,* 15:41–51, 2007.
6. Quental N., Lourenco J.M. and da Silva F.N. Sustainable development policy: goals, targets and political cycles, *Sustainable Development, 19(1):15–29, 2010.*
7. Source on the Web: http://www.un-documents.net/our-common-future.pdf
8. Elkington, J. Towards the sustainable corporation: Win-win-win business strategies for sustainable development. *California Management Review,* 36(2): 90–100, 1994.
9. Sourced from Venkatesh, G. Future prospects of industrial ecology as a set of tools for sustainable development. *Problems of Sustainable Development.* 7(1): 77–80, 2011.
10. The Gini coefficient, also known as the Gini index or Gini ratio, is a measure of statistical dispersion to represent the income distribution of a nation's residents, and is the most commonly used measure of inequality. If the coefficient is zero, it represents perfect equality; if it is equal to one, it depicts perfect inequality. It was developed by the Italian sociologist Corrado Gini in the early 20th century.
11. Vilfredo Pareto postulated that 80% of the wealth generated in an economy is often owned by 20% of the population.
12. Fuller S. Life-Cycle Costing Analysis. Whole Building Design Guide, National Institute of Building Sciences, USA, 2007.
13. Venkatesh G. PhD thesis – Systems Performance Analysis of Oslo's Water and Wastewater System, page 31. Norwegian University of Science and Technology, Trondheim, Norway-7491. ISBN 978-82-471-2623-3, 2011. Accessible online at <http://urn.kb.se/resolve?urn=urn:nbn:no:ntnu:diva-12664>
14. From the myth that an ostrich buries its head in the sand when it is threatened or scared and feels that it is safe thereby.
15. The product being used by the little girl in the photograph taken in Ghana is the LifeStraw water filter, which has found a market in Africa. It has been designed, manufactured and marketed by the Danish company **Vestergaard Frandsen**, and is a very good example of selling a product at a very affordable price, and sustaining health thereby.
16. This is from the Bible, Matthew 6.24.
17. Source on the Internet: http://www.lifecycleinitiative.org/starting-life-cycle-thinking/life-cycle-approaches/social-lca

18. Employment, as you will read in the next section, is a socio-economic aspect, and could be included under either the social dimension or the economic dimension, if a separate socio-economic dimension is not created. It has been considered as a part of S-LCA here, though in the next section, the author maintains that it is closer to the economic dimension, and can be included therein. This is of course, very subjective.
19. Source on the Internet: http://www.isa.utl.pt/der/ASAmb/DocumentosAulas/Recipe/Handbook%20on%20Life%20Cycle%20Assessment.pdf
20. Source on the Internet: http://eplca.jrc.ec.europa.eu/uploads/ILCD-Handbook-General-guide-for-LCA-DETAILED-GUIDANCE-12March2010-ISBN-fin-v1.0-EN.pdf
21. SIMAPRO, GaBi etc.
22. Sourced from Venkatesh G. Water for All and other poems. Cyberwit.net, Allahabad, India. ISBN: 978-81-8253-562-6, 2015.
23. The author's own definition of the term.
24. Venkatesh G. The four-fold path to governance. *Problemy Ekorozwoju,* 8(2):63–66, 2013.
25. Alegre H., Brattebø H., Cabrera Jr E. and Hein A. Framework for Sustainability Assessment of UWCS and development of a self-assessment tool, Deliverable 31.1, Transition to the Urban Water Services of Tomorrow, 2012, available online at www.trust.i-net.
26. Venkatesh G. PhD thesis – Systems Performance Analysis of Oslo's Water and Wastewater System. Norwegian University of Science and Technology, Trondheim, Norway-7491. ISBN 978-82-471-2623-3, 2011. <http://urn.kb.se/resolve?urn=urn:nbn:no:ntnu:diva-12664>
27. The Economist. Poverty: The Decathlon Deprivation, Pages 71–72, March 23–29, 2013, The Economist Newspaper Limited, UK.
28. Binder C.R. From material flow analysis to material flow management. Part II: the role of structural agent analysis. *Journal of Cleaner Production,* 15: 1605–1617, 2007.
29. Venkatesh G. A critique of the European Green City Index. *Journal of Environmental Planning and Management,* 57(3): 317–328, 2014.
30. Venkatesh G. Triple bottom line approach to individual and global sustainability. *Problems of Sustainable Development / Problemy Ekorozwoju,* 5(2):29–37, 2010.
31. Venkatesh G. Interpreting sustainability using Robert Pirsig's Quality levels: LILA-An Enquiry into Morals. *Problemy Ekorozwoju* (*Problems of Sustainable Development).* 6(2):63–66, 2011.
32. This has been included with permission from Prof Dr Artur Pawlowski, Editor of Problemy Ekorozwoju (Problems of Sustainable Development), published in Lublin, Poland. Permission was granted on the 4th of April 2015. This chapter was accepted earlier for publication as a paper in the said journal, in its June 2015 issue (Volume 10, Issue 2).
33. Please note that this has been considered as a separate dimension for this paper, by the author. One may wish not to do so. The contribution of the infrastructural sector to the GDP is however accounted for under the dimension 'Economic'.
34. This is a short summary of some of the author's published journal papers focusing on sustainability in the urban water-wastewater sector. The citations of the papers appear in subsequent endnotes and readers may feel free to access and read through them. The lead picture is sourced from Water for All and other poems.[19]

35. Venkatesh G. PhD thesis – Systems Performance Analysis of Oslo's Water and Wastewater System. Norwegian University of Science and Technology, Trondheim, Norway-7491. ISBN 978-82-471-2623-3, 2011. <http://urn.kb.se/resolve?urn=urn:nbn:no:ntnu:diva-12664>

36. Alegre H., Brattebø H., Cabrera Jr E. and Hein A. Framework for Sustainability Assessment of UWCS and development of a self-assessment tool, Deliverable 31.1, Transition to the Urban Water Services of Tomorrow, available online at www.trust.i-net, 2014.

37. Venkatesh G., Brattebø H. and Sægrov S. Dynamic metabolism modelling of urban water services – demonstrating effectiveness as a decision-support tool for Oslo, Norway. *Water Research* Vol 61: 19–33, 2014.

38. Venkatesh G. and Elmi R.A. Economic-environmental analysis of handling biogas from sewage sludge digesters in wastewater treatment plants for energy recovery: Case study of Bekkelaget Wastewater Treatment Plant in Oslo (Norway). *Energy,* 58(10):220–235, 2013.

39. Venkatesh G., Azrague K., Eikebrokk B. and Bell S. Triple bottom line assessment of raw water treatment: Application to the municipality of Oppegård in south-eastern Norway. *Environmental Technology,* DOI: 10.1080/09593330.2015.1018337.

40. Venkatesh G. and Schwai M. **HERD / Energy (2013–2015)**; Report of the survey conducted in March 2015, from NTNU, for the project – *Rethinking architecture and energy efficiency in buildings and sustainable development.*