UNITED NATIONS **E**

Economic and Social Council

Distr.
GENERAL

CES/2005/23
4 April 2005

Original: ENGLISH

STATISTICAL COMMISSION and ECONOMIC COMMISSION FOR EUROPE

CONFERENCE OF EUROPEAN STATISTICIANS

Fifty-third plenary session
(Geneva, 13-15 June 2005)

MEASUREMENT OF SUSTAINABLE DEVELOPMENT THE NEED FOR A SYSTEMATIC APPROACH

Invited paper submitted by Statistics Canada*

INTRODUCTION

The objectives of this paper are twofold. First, an argument is presented for a systematic approach to measuring sustainable development. By "systematic" we mean a structured, rigorous approach to translating basic data into policy-relevant information. This we contrast with the looser indicators-based approach to measuring sustainability adopted by many national and international institutions. Second, Statistics Canada's views on the most appropriate frameworks for use in systematic measurement of sustainable development are presented and discussed.

THE NEED FOR SYSTEMATIC MEASUREMENT OF SUSTAINABLE DEVELOPMENT

1. The central argument of this paper is that comparable, comprehensive and conceptually clear information on sustainable development is unlikely to emerge in countries unless a systematic approach to measuring sustainability is adopted. A *system* for sustainable development information, like all such systems, begins with a basis in theory, or a conceptual framework. Based on this conceptual framework, relevant variables are identified for measurement, forming a data framework for the system. These data are then built into a structured analytical framework in which hypotheses about relationships among variables can

* Prepared by Robert Smith.

be validated. These three frameworks are the subjects of detailed discussion in the third section of the paper. They are defined in basic terms below.

2. The conceptual framework comprises the theoretical concepts and associated operational variables that form the very foundation of the information system. The conceptual framework defines the content and the scope of the system. It determines what variables are to be measured and provides the rationale for why they are important using well-grounded theoretical arguments. A sound conceptual framework should leave nothing open to interpretation. Different implementations of the system should not result in inconsistent results because of ambiguity of the basic concepts that underlie it.

3. The data framework of an information system comprises 1) the set of statistical and scientific measurement methods (e.g., sample surveys, scientific monitoring) and related attributes (e.g., measurement units) that are employed to collect the data required for the system and 2) the set of rules that are employed to structure the data once they have been collected (e.g., classification systems and aggregation rules).

4. The analytic framework comprises 1) the set of methods that are employed in analysing the data produced by the system and 2) the approach(es) used in structuring the operational variables to reflect the relationships suggested by the underlying theory (e.g., models or accounting systems). As no single information system is likely to provide all the information relevant or necessary to studying a given problem, there is a need for flexibility and openness in the analytic framework. It must be structured such that it can accept data inputs from other information systems. In the case of a sustainable development information system, this translates into a need to accept data from pre-existing information systems in the social and economic realms.

5. Measurement of sustainable development through a system designed carefully in terms of these three frameworks should bear the desirable characteristics noted above; that is, comparability, comprehensiveness and clarity. The system's firm grounding in theory ought to ensure consistency and clarity in measurement, both over time and from issue to issue, as good theories are not prone to constant change. This grounding also provides a disincentive to frequent changes in the basis for measurement, as making any change means either refuting the theory and replacing it with something better or simply ignoring it. The point is not that measurement must never change – theories evolve and so must measurement systems. When measurement systems do change, though, it should be for well-founded reasons and, hopefully, not too often.

6. The translation of the conceptual framework into the data and analytic frameworks ought to ensure comprehensiveness in measurement, or at least the goal of comprehensiveness. All the relevant variables ought to be identified in principle in the data and analytic frameworks; whether they are actually measured is then mainly a matter of resources.

Measurement of sustainability based on indicators

7. National and international efforts to measure sustainable development to date have focused largely on the use of sets of diverse indicators covering the so-called "three pillars" of sustainability: economy, society and environment. Such sets have been developed by the UN, in Sweden, in the United Kingdom and in Germany, to name some of the more prominent examples. The great advantages of this approach are its flexibility and its comparative ease of implementation. What it lacks, we believe, are the desirable characteristics of a systematic approach noted above. Indicator sets do not generally produce information that is comparable across time, across issues or, importantly, across countries. Nor do they necessarily produce comprehensive information; whether this is so or not is a function of the comprehensiveness of available data rather than an inherent characteristic of the approach. The reason for these shortcomings lies in the fact that, rather than having a firm basis in theory, the indicators approach is strongly influenced by practical considerations of data availability and "stakeholder" acceptability.

8. While no one would dismiss the importance of practical considerations in developing information, we question whether it is possible to provide sound information on sustainable development, or any other matter, if practicality is the primary driver in determining what gets measured and what does not. An obvious problem is that what is considered practically important in one instant can be quickly displaced if data availability changes or stakeholder interests shift in a new direction. Another is that practical considerations alone rarely reveal that which is essential to understanding a problem; for this, a resort to theory is necessary. Related to this is the fact that practical considerations often crowd out critical analysis. This is seen in the popularity of the three-pillar view of sustainable development, in which logic reveals a basic weakness. Any concept that purports to address all dimensions of an issue – as does the three-pillar approach – cannot in fact address any issue clearly (more is said on this point below). Yet this view prevails because it is practically workable. No stakeholder group feels the need to be overly critical because all can find their place within it.

9. Indicator selection that proceeds from the three-pillar view is faced with an almost infinite set of possibilities, all under the heading of "sustainable development information". By defining sustainable development to include all that is economic, social and environmental, and because no clear theory underpins the approach, the three-pillar view offers no rigorous basis for debating the relative merits of indicators. Final choices in the process end up being determined, as noted, mainly by data availability and by the relative bargaining strength of different stakeholders.

10. Lack of a clear basis for deciding what to measure is one weakness of the three-pillar approach to developing sustainable development information. Lack of comparability is another.

11. Sustainable development is a goal that transcends borders. All countries face sustainability challenges and many of these challenges are similar, if not identical, from one country to the next. Some challenges are indeed global in nature, defying any unilateral effort at their resolution (e.g., climate change, long-range pollutant transport). A strong case exists, therefore, for building sustainable development information that is comparable across nations. If nations face issues that are broadly similar, solutions will surely be found more quickly if all work from the same information in addressing them. This has clearly been the case over the last

50 years in the area of economic policy. The existence of a common approach to measuring the economy based on systems of national accounts has made it much easier for nations to band together in addressing both national and international challenges. Managing the so-called "debt crisis" of the early 1980s would have been much more difficult, for example, had each country measured levels of indebtedness in different ways or, worse, chosen not to measure indebtedness at all.

12. Without comparable information across nations, assessment of progress toward sustainability is much more likely to be a subjective than an objective matter. Even within a given nation, lack of external comparability may negatively affect the quality of information. Governments are more likely to change their approach to measuring sustainability over time if there is no incentive to maintain alignment with the approaches in other nations. This is evidenced by the fact that few countries, having selected as set of sustainable development indicators, manage to maintain the set substantially unchanged over more than a few years. The situation internationally is similar; what is arguably the flagship international effort at measuring sustainability through a set of indicators, that of the UN Commission on Sustainable Development, has been subject to nearly constant revision since its first creation. Given the importance of temporally consistent information in assessing sustainability (it is, after all, an intertemporal objective), such changes frustrate efforts to determine the true trajectory of a nation, or the world, *vis à vis* sustainability.

13. As these examples illustrate, the indicators-based approach to measuring sustainability does not guarantee comparable information over time within a given nation. The approach's roots in practicality all but ensure that this is the case among nations too. Available data differ from country to country, as do the stakeholder interests represented in indicator selection. The effect is that an indicator set developed in one country is very likely to differ, perhaps significantly, from those developed elsewhere. A quick review of the major national and international efforts at measuring sustainability using indicators reveals this to be true today. No two institutions measure sustainable different using the same set of indicators.

Moving beyond the indicators approach

14. The foregoing has argued for a rigorous, systematic approach to measuring sustainable development. Such an approach has been noted to have several desirable characteristics that the indicators-based approach lacks. The systematic approach is, though, much more demanding in design and implementation. Given this, and the fact that resources to measure sustainability are limited, why should countries even consider moving beyond the practical indicators-based approach?

15. Clearly, gaining agreement on a system for measuring sustainable development and its underlying frameworks will not be easy. Some would argue that agreement is not possible at this time and that countries are right to proceed down whatever practical measurement paths they believe best suit their needs. Measuring sustainability systematically is too complex they might say, and our understanding of how the environment is related to human development is

often too rudimentary. While we accept that this makes the challenge more difficult, we believe it should not be used as reason to avoid it altogether.

16. Not to face the challenge of measuring sustainability systematically means risking the ultimate failure of sustainable development as guide to public policy. Citizens around the world are concerned about the environment's capacity to support on-going human development. They are asking questions that are among the most important the world faces today. If, under the guise of sustainable development information, governments cannot provide them with answers that are consistent and clearly useful in solving real problems, the concept will not fulfil its promise of integrating environment into decision making.

FRAMEWORKS FOR A SUSTAINABLE DEVELOPMENT INFORMATION SYSTEM

17. Information is never created for its own sake. Rather, it is created in the context of answering a particular set of questions. To take a classic example, the development of modern macroeconomic information was motivated more than 60 years ago by the desire to alleviate the misfortunes caused by the ups and downs of the market economy.
Our interest here is in information to assess sustainable development, which implies a different set of questions. These might be summarized in the following problem statement:

> **What are the ways in which the environment contributes to human development and how does human interaction with the environment enhance or diminish its capacity to make this contribution now and in the future?**

18. The objective is to define a system that can provide the information needed to answer these questions. First and foremost, a conceptual framework is needed for the system. This framework must be based on a sound theoretical understanding of the relationship between the environment and human development. To be successful, it must focus on those aspects of the environment that are crucial to human development and that are subject to human influence. That is, it will have to provide explicit guidance as to what aspects of the environment we must be concerned with measuring and what ones we need not give our explicit attention. In this way, it must do what the three-pillar approach fails to do: offer an explicit basis for deciding among the multitude of measures of sustainability that might be put forward. In our opinion, the most promising conceptual basis for a sustainable development information system is the body of thought around natural capital.

Natural capital as a conceptual framework

19. According to the natural capital theory, the environment contributes to human development through material and service flows.[1] For example, the metals used in manufactured products originate in materials (metallic ores) that have their origin in the environment. Similarly, the environment offers services – ranging from the cleansing of water to the regulation of the global climate – that humans use both directly and indirectly.

20. Accordingly, the focus of measurement in a sustainable development information system must be on the distinct stocks of natural resources and individual ecosystems that are the source of these material and service flows. These stocks and ecosystems are essential to human development and, therefore, they are what must be maintained over time if

development is to be sustainable. Collectively, they are labelled *natural capital*.

21. The dubbing of these stocks and ecosystems natural capital is simply an extension of the economist's long-standing notion of capital as items employed in production that provide long-term benefits. Other terms that could be used equally well are natural wealth, natural heritage or natural patrimony. Although the concept is connected with economic thinking, it is important to note that use of the term "capital" by no means limits the consideration of the benefits of natural capital to just market benefits. On the contrary, although market benefits are clearly part of what natural capital offers, the full range of benefits extends well beyond them. It includes benefits such as the aesthetic enjoyment of nature and the use of water provided freely by nature, neither of which is contingent upon a transaction in the market.

22. Before going further with the discussion of natural capital, a word is needed on other forms of capital and their relation to sustainable development. Many commentators, including some who subscribe to the capital approach, would argue that sustainability is not only about the relationship between the environment and development. It must, they would argue, also consider the relationship between social and economic variables and development. After all, it is not just the environment that determines the development options open to a population. This idea lies behind the three-pillar view of sustainable development criticized earlier as being logically unable to provide clear guidance on particular issues.

23. If sustainable development cannot logically be about sustaining the economy, society and the environment all at the same time, what is it about? Our view is that the determination of the variables relevant to measuring sustainability depends on first defining the "object" of sustainability. Put another way, it is necessary to decide what is to be sustained before deciding what variables are relevant to measuring its sustainability.

24. We take the objective of sustainability to be the human enterprise and all its associated social and economic development goals. Given this definition, it is perhaps clearer how the three-pillar view can be seen as flawed. A common social variable like average education attainment illustrates the problem. Improving average educational attainment is widely accepted as a social development goal. At the same time, it is typical to see educational attainment listed as an indicator of sustainable development. The problem arises from the fact that a given variable – in this case educational attainment – cannot logically be both an indicator of development *and* an indicator of the sustainability of development. This kind of problem is inescapable under the three-pillar view, since it leaves nothing out of its frame of reference.

25. In our view, sustainable development has operational meaning only if it is defined such that there exists a clear set of variables exogenous to the system to be sustained. Our preference is to define it such that the environment forms the exogenous variables and social and economic goals are the endogenous variables of the system to be sustained.[2] This seems the most neutral of definitions, as it does not privilege either social development or economic development, but recognizes the need to sustain the entire human enterprise.

Having argued for a restriction of the sustainable development information system to just natural capital and its relation to human development, we return now to defining the types of natural capital.

The types of natural capital

26. Three main types of natural capital are identified in the theory: **renewable and non-renewable resource stocks** (i.e., sub-soil resources, timber, fish, wildlife and water), **land** and **ecosystems**. Each makes a different contribution to human development and each is subject to differing impacts from human activity.

27. **Non-renewable resources**: Non-renewable resources (principally the sub-soil resources) represent stocks from which materials can be withdrawn for use in human activity. These materials provide inputs into industrial processes and private activities (home heating for example). Because sub-soil resources do not have the capacity to renew themselves (except in geologic time), these resources are subject to permanent depletion as the result of use.

28. **Renewable resources**: Renewable resources (trees and other plants, fish and wildlife and water) also represent stocks from which materials can be withdrawn for use in the economy. Unlike sub-soil resources, these resources can renew themselves under appropriate conditions. If withdrawals within a given period are less than or equal to natural renewal, then there need be no depletion as a result of human use. Of course, withdrawals are not always less than renewal, so depletion can and does occur. Fish resources are an obvious example.

29. Aside from the possibility of depletion, renewable resources are also subject to qualitative degradation as a result of human activity. Qualitative degradation does not necessarily reduce the absolute size of renewable resource stocks, but makes them less productive or less valuable from a human development perspective. This degradation can be the result of harvesting activities (*e.g.*, changes to the natural age and species distribution of forests, unintended mortality of non-target fish species); of pollution impacts (*e.g.*, acid rain); and of disturbance from urbanisation, agriculture, recreation and other land use changes. This degradation can negatively affect development options because of reductions in use benefits (*e.g.*, lower quality material supplies, reduce aesthetic value) or non-use benefits (reduce options for the future).

30. **Land**: When land is considered as a type of natural capital, it is with reference to its role in the provision of space. Land benefits humans through their appropriation of space for human purposes (dwellings, transportation infrastructure, agriculture, recreation). It also benefits them when they do not appropriate space, but leave it to be occupied by natural process and then enjoy the benefits of the services provided by the processes. Land is not subject to quantitative depletion in any significant way (at least not yet – climate change may change this if permanent flooding of coastal regions becomes a reality). Nor is it subject to qualitative degradation in the same way as renewable resources. However, land areas of specific types can be augmented or diminished as a result of changes in the way in which land is used. For example, increasing use of land for urban purposes necessarily means reduced use of land for other purposes (agriculture, recreation, wildlife habitat, etc.) in areas around growing cities.

31. **Ecosystems**: Ecosystems (*e.g.*, forests as opposed to trees; oceans, lakes and rivers as opposed to the fish in them) provide flows of unpriced services that are used by humans in a variety of ways. The waste assimilation services of rivers, for example, are used by industries and households alike to absorb pollutants that would otherwise have to be disposed of by another means at greater cost. Ecosystems are subject to both quantitative depletion through human activities (*e.g.*, the conversion of forests into urban land) and to qualitative degradation

via the same mechanisms just mentioned for renewable resources.

32. The treatment of ecosystems as capital is the most difficult of the three forms of natural capital. In theory, the correct approach is to observe the services that are provided by ecosystems and to estimate the benefits that these services provide to humans. A list of the major services provided by ecosystems would include cleansing of fouled air and water; the provision of productive soil; the provision of biodiversity; the provision of a predictable and relatively stable climate; the protection from incident solar radiation; and the provision of reliable flows of renewable natural resources.

33. Even if we can identify what the major ecosystem services are, we cannot observe them directly, just as we cannot observe the transportation service that an automobile provides. In the latter case, economic theory has found a means of assessing the value of the automobile as capital even if it is not possible to observe the services it provides directly. The theory says that the present value of the services that will be rendered by the automobile over the extent of its life is exactly equal to the price established for it in transactions between buyers and sellers in a free market. The argument behind this notion is that no rational purchaser would be willing to pay more for the automobile today than the present value of the services that he or she could expect to obtain through the use of it over its life. While this theory may be useful in establishing the value of produced capital goods that are commonly bought and sold, it is of little practical value in establishing the value of ecosystems. Another theoretical approach must be found to evaluating ecosystems as capital.

34. One possible approach to evaluating ecosystems is to consider the quality of their service outcomes. The list of major ecosystem services given above translates naturally into a list of outcomes that are more or less observable and that could be used as the basis for operationalizing the notion of ecosystems as capital. If the outcomes of ecosystems services are constant over time (e.g., air quality is non declining) then one can conclude that the natural capital – that is, the ecosystems – that operate to provide these outcomes are being maintained. Obviously, the measurement of ecosystem service outcomes is by no means straightforward. Nevertheless, it is argued here that this is a conceptually correct means of evaluating ecosystems as natural capital and one that offers promise for measurement.

A data framework for natural capital - operationalization of the theory

35. As noted earlier, the data framework of an information system is closely related to its conceptual framework, with the latter defining the variables that are to be measured in the former.

36. Many of the variables relevant to the natural capital framework have already been alluded to in the foregoing discussion of the theoretical concepts. It is useful to group them into stock, flow and state variables.

37. Stock variables include those related to assessing the extent of natural capital at a point in time. Flow variables include those related to assessing the qualitative and quantitative changes in natural capital from one period to the next. State variables include those related to assessing ecosystem service outcomes. State variables are distinct from stock variables in that the former are inherently qualitative while the latter are quantitative.

38. It is straightforward to see the need for stock variables in operationalizing the natural capital framework. The framework leads necessarily to the measurement of stocks because they provide the material and service flows used in human development. The relevant stocks include traditional natural resources (timber, minerals, fossil fuels, water, fish) and land. The size of these stocks is important from a sustainability perspective because their size determines the extent to which humans can rely upon them as sources of environmental materials and services.

39. While it is straightforward to see that stocks must be measured as part of a natural capital-based system, their measurement can be far from straightforward. Physical measures of natural assets (tonnes of mineral ore, hectares of timber and the like) are relatively easy to produce in most countries, but they present a problem of non-commensurability. There is no obvious way to compare stocks of timber measured in hectares against stocks of oil measured in metres cubed. If one is increasing while the other is decreasing, what is the meaning for sustainability? This problem can be addressed, in principle, by measuring all stocks using a common numeraire, typically money. There are a host of difficulties associated with the valuation of natural capital stocks in monetary terms, not the least of which is suitability of market prices for valuing natural capital when the market itself ignores most environmental externalities. Other difficulties include the lack of appropriate valuation methods, especially for ecosystem services, and the lack of consensus regarding the methods that do exist. Even where agreed upon methods exist, data to implement the methods can be difficult to obtain. Clearly, the limited possibilities for valuation of natural capital are a practical weakness of the approach. Like all practical weaknesses, though, it is amenable to correction through investment of time and talent.

40. The second broad set of variables to fall out of the natural capital framework includes the flow variables. These are important because they determine the changes in size of natural capital stocks from one period to the next. Recalling the problem statement on p. 5, the flow variables explain “how human interaction with the environment enhances or diminishes its capacity to contribute to human development now and in the future.”

41. Several categories of flow variables are relevant. Variables measuring the human activities that lead to quantitative changes in natural capital stocks show how activities in one period reduce (or augment) the availability of natural capital in future periods. These measures include timber harvests, oil and gas production and other resource extraction activities, as well as their mirror images - planting of new trees, discovery of new oil and gas reserves and other resource augmenting activities.

42. The second category of flow variables includes those describing human activities that lead to qualitative changes in natural capital stocks. Among the most important of these are

measures of waste flows; for example, household solid wastes and emissions of various types from industrial facilities.[3] The impact of wastes on natural capital is mainly seen in the degradation of the capacity of ecosystems to provide the service outcomes humans rely upon to, among other things, keep them healthy. Excessive introduction of sewage wastes can, for example, overcome the assimilative capacity of local aquatic environments, reducing their capacity for the provision of clean water. It is increasingly understood that waste materials can have more profound, global effects as well, on the capacity of the ozone layer to protect us from the sun's radiation for example.

43. Changes in land use and land cover are another important flow measure related to qualitative changes in natural capital. Although land cannot be quantitatively increased or decreased to any great extent, human activities regularly change the land's qualitative features in ways that impact its ability to provide needed environmental services. Sometimes these changes alter the availability of certain types of land (e.g., good farmland is paved over for urbanization) and other times they alter the availability of land for ecosystem functioning, which then alters the flow of ecosystem services available to humans. Both types of change are of interest in a sustainable development information system.

44. A final category of flow variables includes what might be called "environmental investments." These are expenditures made with the purpose of reducing the impacts of current human activities on natural capital (*e.g.*, by reducing waste flows or resource consumption) or correcting the results of activities from earlier periods (*e.g.*, decontaminating abandoned industrial lands). These variables are less directly related to understanding sustainable development than the others mentioned so far; it is more revealing to measure the actual changes in waste flows resulting from investments in, for example, air pollution control equipment than to measure the investments themselves. Still, knowing how large these investments are in comparison with non-environmental investments and knowing who makes them is useful information when designing and assessing policy in support of sustainable development.

45. The last set of variables relevant to operationalizing the natural capital framework includes the state variables. These are those that are required to qualitatively measure the outcomes of ecosystem functions. As argued earlier, it is theoretically preferable to measure ecosystems using some sort of stock variable, just as timber or fish can be measured. Unlike timber and fish, ecosystems are not measurable in any meaningful and straightforward way as discrete entities. The alternative suggested here is to measure them indirectly by considering the quality of their outcomes. This implies measurement of, among others, air quality, water quality, biodiversity and soil fertility.

46. The measurement of ecosystem outcomes is the least well developed – and arguably the most important – element in operationalizing the natural capital framework. Science still does not offer a complete picture of the ways in which ecosystems function, especially in regard to the interaction between ecosystems. Thus, we cannot name with certainty all the ways in which humans benefit from ecosystem functions. Progress is being made however, particularly in the guise of the "millennium ecosystem assessment" currently underway under the auspices of the UN. As scientific understanding of these complex systems evolves, so too must the thinking on how best to measure ecosystems and their functions in a sustainable development information system.

Approaches to data measurement

47. Having defined in general terms the types of variables that a sustainable development information system based on natural capital must cover, we now turn our attention to the mechanisms by which they can be measured.

48. It is clear that the variables making up the data framework of a sustainable development information system are broad in scope and complex. They include variables that can be measured via the mechanisms normally employed by statistical offices, as well as variables that are properly the domain of scientific measurement. This implies the practical need for the involvement of more than just statistical agencies in the building of the information system. Also required are government agencies with the responsibility for the management of natural resources, land and ecosystems.

49. The measurement of the physical variables related to natural capital stocks does not generally fall within the domain of statistical agencies. Measurement of timber stocks, oil and gas reserves, land area, water resources and so on requires know-how and methods normally found in other agencies. This is not to say that statistical agencies have no role to play however. There are at least two ways in which the expertise found within statistical agencies can contribute. One is in the valuation of natural capital stocks, an exercise that involves the combination of physical data from resource management agencies with economic data from statistical agencies. Indeed, it is often necessary to use firm-level economic data in these valuations, making statistical agencies effectively the only place where such work can be done.

50. The second way in which statistical agencies can contribute is through statistical modelling. Measures of timber stocks are a good example, since actual physical measures of timber stocks (at least in a country the size of Canada) are available only at lengthy intervals. Modelling can be used to fill the gaps between the infrequent direct observations to produce annual timber stock estimates. The expertise needed for such modelling is not exclusive to statistical agencies, but the culture within such agencies is, arguably, more open to use of modelled data than in other agencies. Statisticians are accustomed to imputing missing variables in surveys and in national accounts and understand that the trade-off of data quality for data completeness and timeliness is often worth making.

51. The flow variables associated with measuring sustainable development are better suited to collection by statistical agencies. The exploitation of natural resources, the production of wastes, the modification of land and the investment in environmental protection are all activities carried out by the institutional sectors that are the normal target of statistical monitoring. They are, to varying degrees, amenable to measurement using standard sample surveys. This said, it must be noted that few statistical agencies are actively involved in these areas. Programs of measurement of resource exploitation were once common in statistical agencies, but, with the possible exception of energy statistics, are increasingly the victim of constrained budgets. Measurement of pollution emissions, even if within the capacity of statistical agencies, has never been common practice. Measurement of land use is common, but is generally restricted to land occupied for human purposes (farmland and built-upon land). Measurement of environmental protection activities is reasonably common among larger agencies, but far from universal.

52. The state variables associated with measuring sustainable development are those that are furthest from the domain of statistical agencies. The quality of ecosystem functions is properly the domain of scientific measurement. Here too there is some possibility for statistical modelling to play a role, but the systems being modelled are much more complex. Any such modelling would have to be a combined effort of scientists and statisticians.

An analytical framework for natural capital

53. In this final section of the paper, we address the choice of analytical framework for the sustainable development information system. As noted earlier, the role of the analytical framework is to organize the variables defined by the data framework for maximum usefulness in answering the questions posed in the problem statement. Put another way, the framework's role is to structure basic data so that they become analytically useful.

54. The first question in problem statement posed above was "how does the environment contribute to human development?" The natural capital framework suggests this happens through the provision of materials and services that provide various sorts of benefits. One role of the analytical framework must be, then, to organize basic data on natural capital to reveal the extent to which the environment is capable of providing these benefits. This leads to the notion of a summary statement of natural capital stocks structured along the lines of major classes of stocks; in other words, a natural capital balance sheet. If the entries on this balance sheet could all be measured meaningfully in monetary values, then it would be possible to produce a single aggregate measure of natural wealth that would be, in principle, an ideal measure of sustainability.

55. The other question posed in the problem statement was "how does human interaction with the environment enhance or diminish its capacity to provide benefits now and in the future?" The answers to this question are wide ranging and so must be the analytical framework. It must provide the means for organizing data on resource consumption, waste flows and environmental protection investments. Moreover, it must do so in a way that allows these data to be integrated with the economic and social data that describe the human activities responsible for these natural capital-related flows.

56. Clearly, the analytical framework required to build a sustainable development information system based on natural capital is complex. Fortunately, there is no need to create one, as the world community has already developed a suitable analytical framework. This is the *System of Environmental and Economic Accounts 2003* (SEEA) prepared recently under the auspices of the United Nations, the OECD, Eurostat, the IMF and the World Bank.

57. The SEEA describes in detail the rules for the development of accounts for individual natural resources, land and ecosystems. It also shows how these individual accounts can serve

as the basis for compilation of a natural capital balance sheet integrated with the national balance sheet for economic assets described in the System of National Accounts (SNA).

58. The SEEA also details the development of material flow accounts suitable for organizing data on resource consumption, waste flows and environmental protection expenditures. It shows how these accounts can be integrated with the input-output accounts of the SNA. Integration of data on natural capital-related flows with economic data from input-output tables offers considerable analytical power for studying the ways in which human activities affect the environment's capacity to provide benefit flows.

59. In its most complex component, the SEEA outlines how qualitative changes in natural capital state variables can be reflected through the modification of the aggregate economic measures of the SNA (*e.g.*, income and saving). These recommendations are controversial and far from universally agreed upon. They do, nonetheless, represent some of the best thinking available on how to reflect changes in the state of natural capital in a framework suitable for measuring sustainable development.

FINAL THOUGHTS

60. If the SEEA represents a nearly ideal analytical framework for a natural capital-based information system, why do only a handful of countries use environmental accounts as a basis for measuring sustainable development? There is no single answer to this question, but we believe it is partly due to inadequate dialogue between those who promote the use of environmental accounts (mainly statistical agencies) and those with responsibility for measuring sustainable development (mainly environmental policy agencies).

61. Statistical agencies have promoted the use of environmental accounts as a means of improving the analytical usefulness of environmental information for more than a decade now, with mixed success. While some agencies have had success at certain points in time in demonstrating the relevance of environmental accounts, it is fair to say that none has succeeded in building such a loyal following for its accounts that they could be considered essential elements of its statistical program. Put another way, no agency has succeeded in finding the overarching *raison d'être* for environmental accounts. Where successes have come, they have come from linking environmental accounting with specific environmental policy goals (e.g., dematerialization of production, reduction of air pollution, analysis of climate change). This has provided justification for certain types of environmental accounts, mainly material flow accounts, but not for the fully-elaborated SEEA system. Without a clear reason to invest in fully-elaborated accounts, most countries have shied away from the challenge and expense. Linking environmental accounts with the measurement of sustainable development may provide the clear reason that has been missing so far.

62. As discussed earlier, by far the most common approach to measuring sustainable development today is through sets of loosely integrated indicators that reflect the three-pillar view of sustainability. The agencies responsible for these sets appear willing to accept the conceptual weaknesses of the approach (to the extent the weaknesses are recognized at all). The approach is flexible enough to ensure that each stakeholder enjoys its own "space" within the process. Despite its broad acceptance, we believe another approach is needed. The current approach seems incapable of producing clear policy quidance and, therefore, risks sacrificing

the support sustainable development has gained as a policy goal. Can this situation be turned around? Is it possible to argue successfully for a more rigorous, systematic approach to measuring sustainable development based on a natural capital framework and expressed through environmental accounts?

63. If this is to happen, we believe statistical agencies must play a stronger role in the debate. Statistical agencies have a rich history in establishing the relationship between social and economic information and social and economic policies. This is perhaps best demonstrated by their role in championing and building the SNA as the information system of choice for studying economic development. They have been comparatively silent on the relationship between environmental information and environmental and, especially, sustainable development policy. If the benefits of systematic environmental information are to be understood and accepted by those responsible for sustainable development policy, statistical agencies will have to speak up. We have proposed an alternative to the indicators approach here. Perhaps the natural capital approach we have presented is inadequate. Or perhaps a natural capital approach is not best at all; some other approach may exist that is clearly preferable. The answers to these questions can only be revealed if the topic becomes one of open debate.

[1] In this context, these service flows are broadly defined to include pure utility flows, for example the psychic enjoyment of wilderness appreciation.
[2] Other definitions are possible. For example, the economy could be identified as the object of sustainability, making both social and environmental variables exogenous.
[3] Wastes in this context include all gaseous, solid and liquid materials rejected into the environment from human activity.

* * * * *