# The Role of Orientors in Modelling Sustainable Development

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**Abstract**: The issue of sustainable development concerns the dynamics of the interactions of human systems with the natural environment and vice versa. These complex interactions can be modelled at different spatio-temporal scales. The classic studies of modelling small ecosystems or, alternatively, the metabolism of industrial plants have been successfully undertaken. These essential case studies, however, lack integration with the broader measures of sustainable development. Paradoxically, some of the higher level aggregate measures of sustainability can not be linked to the detailed lower level case studies. In order to overcome this disparity between local case studies and more aggregate measures of sustainability new methods are required. Bossel's concept of orientors may fulfil this need. This concept has the potential to integrate the *fundamental* concepts of sustainable development at different levels of complexity. The idea of an orientor is explained including the underlying concepts, the method of calculation and a way of visualising development by use of an orientor star diagram. An example illustrates the way in which the orientor concept can be used in dynamic modelling of sustainable development. It is suggested that further developments along these lines will, at least, permit the integration of dynamics spatio-temporal models via orientors with actual indicators and measures of sustainable development at different scales. The paper presents a case for considering Bossel orientors as a way of making progress in measuring and modelling sustainable development.

**Keywords**: Orientors; Modelling; Sustainable development

## 1. INTRODUCTION

Sustainable development gained international prominence with the publication of the so-called Brundtland report in 1987 [WCED, 1987]. Since, then there has been a massive growth in the number of papers defining and attempting to measure development that is sustainable. There are over one hundred definitions of sustainable development and this is a conservative estimate [Pezzey, 1992; Moffatt, 1996]. Despite the massive number of definitions a general consensus is being achieved over the meaning of sustainable development-even if researchers differ over the *precise* definition of the term. Generally, sustainable development can be conceptualised as a process concerned with providing a socially just, economically viable system within the bounds of the ecologically possible for current and future generations. Whilst the debate over definitions of sustainable development has subsided there remains the difficult task of measuring development to see if the actual pattern is sustainable. Numerous measures have been produced including some 134 for OECD nations [OECD,1991; Moffatt, 1996]. When attention is directed to modelling sustainable development there are numerous approaches being used [Moffatt, 2001]. These approaches include static models based on neo-classical economics using the weak measure of sustainable development. There are also a growing number of attempts to develop dynamic economic ecological models of sustainable development at regional scale and at the level of individual businesses [Costanza et al, 1990; Moffatt and Hanley, 2001]. These different approaches reflect, in part, the problems being investigated as well as the underlying theoretical models being used. The basic idea behind any approach to modelling sustainable development is to see if current practices are sustainable or not. If they are shown to be unsustainable then the impact of policies on changing an unsustainable path onto a sustainable trajectory can be explored by simulating different scenarios. Is it possible that despite the differences in approaches to modelling sustainable development that a more primitive or fundamental set of criteria can be used? In this paper we will examine one such set of fundamental approaches to modelling sustainable development at different spatio-temporal scales. In particular it is argued that

Bossells concept of orientors represents one important way of making progress in this area of inter-disciplinary modelling of sustainable development process.

In the following section Bossels concept of an orientor is explained including the underlying concepts, the method of calculation and a way of visualising development by use of an orientor star diagram. The third section then illustrates the ways in which the orientors concept can be integrated into these integrative models to represent both a basis for the models and to illustrate where policies and practices if reached would cause the entire systems to collapse. The relationship between orientors and fuzzy- logic is noted. Finally, ways in which we can progress in this area of modelling sustainable development will be suggested.

## 2. THE ORIENTORS CONCEPT

In a series of publications Bossel has argued that an orientor is a useful device for describing and evaluating the development of ecosystems and the way they move towards or away from a sustainable trajectory [Bossel 1987, 1992, 1996a, 1996b]. Whilst sustainable development is difficult to define it can be argued that it is a process which combines sound economics system with a socially just distribution of goods and these take place well within the constraints of the surrounding ecological systems. Furthermore, sustainable development is concerned with the problems of intra and inter-generational equity [WCED, 1987; Pearce and Barbier, 2000]. Whilst there is an on-going debate about the best way to understand sustainable development and put it into practice most ecologists would argue that all our economic activities must not significantly damage the surrounding ecosystems. Currently, many ecosystems are being destroyed and these are well documented. These economic-ecological problems have been recognised as a sustainable development gap.

A sustainability gap has been identified in many studies. The best definition is as follows, " a sustainability gap indicates the degree of consumption of natural capital, either in the past or present, that is in excess of what is required for environmental sustainability. For state indicators, the gap indicates the extent to which natural resource stocks are too low, or pollution stocks are too high. For pressure indicators, the gap indicates the extent to which the flows of energy and materials contribute to environmental depletion and degradation" [Ekins and Simon, 1999, p.49]. This gap indicates that the distance between sustainable use of a system and its over-exploitation has to be narrowed. In fact our socio-economic activities have to be constrained within the environmental /ecological constraints on any system, at least, if we wish to pursue development that is sustainable.

Bossel has argued that *any* earthbound environmental and socio-economic system can be characterised by six fundamental environmental properties. These are as follows: 1 normal environmental change; 2 scarce resource; 3 variety; 4 variability; 5 change; and 6 interaction with other systems. These fundamental properties of any environment are each unique i.e. each property cannot be expressed by any other combination of other fundamental properties. As he notes "if we want to describe the systems environment *fully*, we have to say something about *each* of these properties" [Bossell, 1998, 20]. In addition to satisfying these fundamental environmental properties Bossel then argued that a set of basic orientors can be used to describe and evaluate the way in which integrated systems change.

Initially Bossel described only six orientors [Bossell, 1992] but later this was developed to include seven orientors operating on six levels at different hierarchical levels in the real world [Bossell, 1999]. The seven orientors are (X) existence; (P) psychological needs; (E) effectiveness; (F) freedom of action; (S) security; (A) adaptability and ( C) coexistence. These basic orientors operate at different levels in integrated systems (i.e. systems combining physical-ecological relationships and socio-economic links [Bennett and Chorley, 1978]). Bossel makes a useful distinction of identifying six subsectors namely (I) infrastructure; (E) economic system; (S) Social system; (H) Individual development; (G) Government and (R) Resources environment and future. These six sub-sectors are not an ad hoc classification but reflect the essential parts of the anthroposphere which interact with the rest of the natural systems at different spatial scale and at different time scales. By combining the seven orientors with the six sub-sectors Bossel is then able to identify over 200 measures of sustainable development within this holistic framework [Bossel, 1996]. Obviously, each cell in the six by seven environmental properties versus orientors matrix can contain more than one measured parameter.

The method for determining orientors is quite straightforward. First, for each of the seven orientors on the six sub-sectors one or more measures of sustainability are used. It should be noted that measures (indicators) have to be defined for two sets of questions: (1) with respect to the

viability of the sector system itself and (2) with respect to its contribution to the rest of the community (plants, animals, humans) as a whole (Table1). Next, the individual measures are entered into each cell (note that more than one measure may be entered per cell). Each cell entry may be graded in to a five fold classification: A excellent (4); B good (3); C fair (2); D deficient (1) F fail (0). Finer grades by using + or - signs can also be used. In brief quantitative raw data can be handled into qualitative forms without too much loss of detail over the basic question of whether or not a system is on a sustainable trajectory or not. Whilst it is difficult to discern a pattern in such a table of grades it is possible to replace the letter grades by their numerical equivalent and compute average grades for each of the basic orientor satisfaction (by dividing by 6x2=12). Such a simple transformation allows the seven basic orientors to be plotted as an "orientor star "diagram with seven rays, where the length of each ray represents the (average) degree of satisfaction of that basic orientor in the system. A hypothetical example of an orientor star diagram representing the "Rich North" and "Poor south" in the global economy is shown in Figure 1. It will be observed that by comparing the pattern and size of the orientor stars for different paths of development it can be observed that the viability and sustainability of both areas are at stake. The advantage of the orientator star figure is that it is easy to visualise whether or not a country is " sustainable " or not. In this hypothetical example the rich North is nearer to being sustainable and the Poor South country falls along way behind on many, but not all, orientators.

Given that sustainability is concerned with the dynamics of economic-ecological development the orientors can be mapped, using star diagrams, through time. In a global study of the ecosphere using orientors Bossel has shown that for the period 1950-200 many aspects of change have occurred. In particular the human system have improved but co-existence has deteriorated due to the rising income gap between rich and poor. The support systems have improved but remain at low levels. The natural environmental system continues to be degraded. The total system has shown a reduction in sustainability over the period. The human and support systems are thriving at the expense of the environment. Yet it is safeguarding environmental systems which is essential for any long-term patterns of sustainable development [Bossell, 1999]. By examining changes in the orientors through time, the actual development of a system can be illustrated and the implications of alternative paths would have on system viability and sustainability can be assessed as part of strategic environmental decision making. In the following section it will be argued that we can use this approach as part of the process of modelling sustainable development.

**Table 1** An example of grading orientors (see text for explanation)

| **Basic orientor** | **Infrastructure** | **Economic system** | **Social system** | **Individual development** | **Governance** | **Resources and Environment** |
|---|---|---|---|---|---|---|
| | I<br>System i total<br>N | E<br>System i total<br>N | S<br>System i total<br>N | H<br>System I total<br>N | G<br>System I total<br>N | R<br>System I total<br>N |
| **Existence (X)** | | | | | | |
| **Psychological needs (P)** | | | | | | |
| **Effectiveness (Ef)** | | | NB Any cell can contain several measures | | | |
| **Freedom of action (F)** | | | | | | |
| **Security (S)** | | | | | | |
| **Adaptability (A)** | | | | | | |
| **Coexistence** | | | | | | |

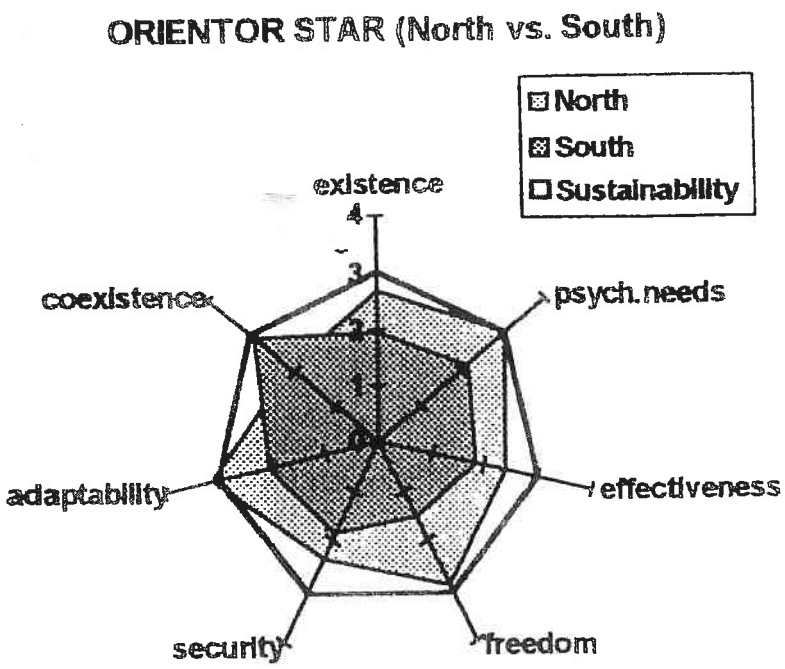


**Figure 1**Orientor assessment for the "rich North poor South" development paths [After Bossel 1996].

## 3. TOWARDS AN INTEGRATION OF ORIENTORS WITH DYNAMIC SUSTAINABLE DEVELOPMENT MODELS

Despite the vast literature concerned with defining and measuring sustainable development very few studies have moved on to model current systems to determine whether or not they are sustainable. There are, of course, some studies which have been undertaken. These include the neo-classical economics based models of weak sustainability [Pearce and Barbier, 2000]. Alternative models of sustainable development have been derived from ecological literature [Costanza et al, 1990]. More interdisciplinary work on dynamic hierarchical models have been developed along with input output models [Moffatt et al 2001]. It is to an early example of the latter group of models which will be used to illustrate the ways in which orientors can be integrated with dynamic model of sustainable development.

The Limits to Growth models were an early and controversial attempt to examine sustainable development [Meadows et al 1992]. Each of the limits to growth models consisted of five state variables (population growth, resource use, pollution, agriculture and capital investment) connected by a set of non-linear feedback loops. The feedback loops were either positive or negative and the resultant behaviour of the model was that if present trends in population growth and pollution continued then the world would suffer an economic and ecological collapse. These models were subject to detailed criticism [Cole et al, 1974] but, for the purpose of this paper, it is possible to simplify the world models and link them to orientors to indicate the ways in which the latter can contribute to sustainable development policy making.

In this simplified model six of the seven orientors can be used to show when a specific orientor falls below a critical threshold. Existence (X) of population, for example, would be compromised if its number falls below a critical level. Similarly, the effectiveness (E) of the environment would be unsustainable if its quality falls below a certain minimum. It is therefore possible to write constraints in the model of the real system by setting population >0.1 and quality >0.1. A similar argument can be developed for Freedom of action (F); Adaptability (A) ; Coexistence (C) and Security (S) can all be included as constraints on the system . If the population remains within this set of constraints then the system is sustainable; if, however, the range of any parameter falls beneath the threshold of the orientors then the system as a whole is unsustainable. Table 2 specifies the business as usual scenario of the unsustainable world model and the critical threshold of the orientors for the sustainable scenario.

**Table 2.** Orientors for the unsustainable and sustainable scenarios of a simple world model.

| ORIENTOR | PARAMETERS UNSUSTAINABLE | PARAMETERS SUSTAINABLE |
|---|---|---|
| EXistence | Population 1 | Population > 0.1 |
| | Quality 1 | Quality > 0.1 |
| EFfectiveness | Quality/Capital 1 | Quality/Capital >0.4 |
| Freedom of action | Consumption 0.1 | Consumption >0.8 |
| | Quality 1 | Quality > 0.5 |
| | Deaths/Population 0.01 | Deaths/Population < 0.02 |
| Security | Deaths/births 0.3 | Deaths/births >0.9 |
| | Death/births deviate >5 | Death/births deviate < 1.1 |
| | Regeneration/degeneratio n >5 | Regeneration/degeneratio n >0.95 |
| Adaptivity | Quality 1 | Quality > 0.5 |
| | Population > 6 | Population < 4 |
| | Capital growth rate 0.05 | Capital growth rate >0.05 |
| | Capital 1 | Capital > 0.5 |
| Co-existence | Quality 1 | Quality > 0.5 |

It will be noted that orientors are similar to the constraints set up in linear programming. In dynamic simulation modelling, however, the orientors can be set up as table functions in STELLA or similar simulation languages. It will also be noted that the table function set up in STELLA can also be written as fuzzy-logic relationships. The latter have proven to be useful in studying sustainability at different levels using the Sustainability Assessment using Fuzzy Logic (SAFE) [Phillis and Andriantiatsaholiniaina, 2001].

Obviously, more complex models of sustainable development would have many other parameters and associated orientors. It would, therefore, be useful to measure the overall orientor satisfactions of the system by simply summing up the weighted orientor contributions and divide the sum by the number of orientors. Further empirical research together with more detailed modelling of real systems is required to discover whether or not this averaged orientor is actually synonymous with sustainable development.

## 4. CONCLUSION

This paper has described briefly Bossell's concept of orientors as fundamental building blocks for making development sustainable. The idea was developed over 24 years ago [Bossel, 1977] and has recently been applied to case studies of ecological and socio-economic systems [Muller and Leupelt, 1998]. Despite its apparent complexity the method for developing and using orientors in empirical work is straightforward. It has been suggested that this empirical approach to measuring sustainable development using orientors is closely related to fuzzy-logic which is also used in measuring sustainable development.

When attention is moved from measuring to modelling more complex economic-ecological models it has been demonstrated that it is possible to use orientors as a basis of determining the environmental constraints within which any socio-economic system must remain. Using the early Limits to Growth type of models it was demonstrated that orientors can be used to ascertain the limits in a dynamic system. More research on more complex models of sustainable development needs to be undertaken. In particular the hierarchical dynamic models of the global, national, regional and local systems can also incorporate oreientors. In dynamic simulation modelling of sustainable development the use of orientors has not really been fully exploited - yet on the basis of this preliminary work it appears to have some merit.

Obviously, the ideas developed in this paper are tentative. At present it would appear possible that the integration of dynamic models via orientors with actual indicators and measures of sustainable development at different spatio-temporal scales is achievable. In particular we need to undertake a detailed research programme of empirical and theoretical studies so that the use of orientors can be assessed in detail. At present it would appear that there appears to be a strong case for applying orientors in both empirical and theoretical studies in to sustainable development and associated policy evaluation.The full potential of Bossel's method has yet to be exploited in dynamic simulation modelling.

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