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Responsibility, inequality, efficiency, and equity in four sustainability paradigms: Policies for a shared sea from a multi-country analytical model

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ABSTRACT

This paper develops a theoretical framework for four sustainability paradigms (weak sustainability, a-growth, de-growth, strong sustainability) within cooperative and non-cooperative scenarios, and includes changes in four values (a sense of responsibility to nature and future generations; aversion to inequality for current and future generations). The model assesses the feasibility of sustainability solutions for a shared environment as a function of specific value changes in each country by interpreting these value changes as support for environmental policies. The solutions are defined in terms of consumption, use of the environment, and welfare of representative individuals in each country; they are characterised by efficiency and equality at both intra- and inter-generational levels; and they are checked for internal consistency and consistency with alternative approaches such as utilitarianism, egalitarianism (i.e., Arneson, Dworkin, Sen), and contractarianism. *Theoretical* insights are obtained by comparing contextual stability and relative effectiveness of the environment's use among countries in alternative scenarios. A case study of the Baltic Sea *operationally* suggests that the currently adopted strong sustainability (i.e., an ecosystem approach) in a non-cooperative scenario (i.e., countries attempt to maximize their own rather than overall welfare) is internally consistent, relatively efficient, and consistent with Dworkin egalitarianism. A-growth was never feasible, but de-growth in which Denmark, Finland, Germany, and Sweden increase environmental protection would increase intra-generational equality; de-growth or weak sustainability in which Estonia, Latvia, Lithuania, Poland, and Russia increase environmental R & D would increase intra- and inter-generational equality; weak sustainability and de-growth consistent with Arneson and Dworkin egalitarianism would improve the environmental status.

1. Introduction

Sustainability can be defined as "social-ecological resilience" [31], where resilience stands for the capacity of a dynamic process of non-linear interactions between social and ecological systems to adaptively adjust and organise its structure and relations to overcome a disturbance while preserving its essential attributes. Continuity and minimisation of environmental and social impacts are typical aspects of sustainable systems. Greenhouse gas emissions (and their consequences, such as temperature increases) and north–south inequality (and its consequences, such as inter-continental migration) are examples of sustainability problems. By disregarding non-linear interactions and by considering steady-state equilibria, Zagonari [46] operationalised sustainability, and analysed four main sustainability paradigms: weak sustainability, a-growth, de-growth, and strong sustainability. Of these paradigms, a-growth and de-growth focus on environmental and social impacts, respectively, whereas weak and strong sustainability focus on continuity: weak sustainability is more concerned about the social system (in terms of welfare) and accepts substitutions between natural and other forms of capital, whereas strong sustainability is more concerned with the ecological system (in terms of resources), and rejects substitutions between natural and other forms of capital. In this context, the economic general equilibrium framework is similar to weak sustainability, whereas the ecosystem services framework is close to strong sustainability. Moreover, continuity is sufficient but not necessary for resilience; that is, an ecosystem can be sustainable if it is disrupted but subsequently returns to its original state, as in the case of fire-regenerated forests. Finally, non-linear interactions and the potential movements between alternative states can be disregarded as a first analytical step, although these features are crucial in subsequent development of sustainability science.

Two main value changes have been evoked to achieve sustainability: a sense of responsibility for nature [29,32,43] or for future generations [23,6], and an aversion to inequality with respect to current or future generations [10,22]. Improved environmental technology and modified consumption patterns can be considered here as context

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changes for any combination of paradigms and values.

The purpose of the present study was to develop a model for the four sustainability paradigms within a single framework that accounts for changes in the four values (a sense of responsibility for nature or future generations; aversion to intra- or inter-generational inequality) and that could be used to socially characterise each country that cooperates (or chooses to not cooperate) in managing a shared environment, such as a sea. To support this goal, a model is developed to assess the feasibility of various sustainability solutions for a shared environment that depend on changes in values that could support specific environmental policies in each country. Analytical solutions will be characterised using the consumption level, the direct and indirect use of Earth's resources (hereafter, 'environment use'), and the welfare level for representative individuals in each country by providing both *theoretical* insights and *empirical* findings. In particular, analytical solutions will be developed to theoretically compare cooperative and non-cooperative scenarios, where cooperative scenarios are represented by maximisation of the overall welfare and non-cooperative scenarios are depicted as Nash equilibria for each country's welfare. Moreover, analytical solutions will be developed to theoretically compare the stability of each solution in response to changes in contexts (here, the value attached to consumption to depict the effect of consumption preferences, and the use of the environment per unit of consumption to depict the effect of environmental technology). Finally, analytical solutions will be developed to theoretically compare the relative effectiveness of environment uses in different countries in alternative scenarios with respect to environment uses under strong sustainability.

These analytical solutions will be applied to the Baltic Sea as a case study to empirically rank the sustainability solutions in terms of their feasibility, stability, and effectiveness. Moreover, two key efficiency concepts (i.e., Pareto and Kaldor-Hicks efficiency with respect to welfare) and two key inequality measures (i.e., Gini and MaxMin inequalities with respect to consumption, environment use, and welfare) will be discussed at both intra- and inter-generational levels. This will empirically reveal the internal consistency of the sustainability paradigms with respect to inequality (e.g., weak sustainability cannot be linked to a large aversion to inequality) and to efficiency (e.g., weak sustainability must be coupled with Kaldor-Hicks efficiency). Finally, three main equity approaches will be described: a utilitarian approach (i.e., Harsanyi), an egalitarian approach (i.e., Arneson for welfare; Dworkin for consumption or environment use; Sen for consumption and environment use), and a contractarian approach (i.e., Rawls) [12]. This will empirically characterize the sustainability solutions in terms of distributive justice. In this context, equality refers to providing the same consumption, environment use, or welfare to all parties, even if that is not a "fair" distribution, whereas equity refers to a "fair" distribution, even if that distribution is not equal.

In other words, from a *positive* perspective, this study will identify for each sustainability paradigm which value changes are crucial to meet sustainability conditions for a shared environment (here, the Baltic Sea) by turning specific value changes (e.g., a sense of responsibility for nature or future generations) in each country into specific environmental policies (e.g., environmental protection and R & D) in each country. The internal consistency of each solution and its consistency with various equity approaches will also be determined by measuring its efficiency in terms of welfare and its effectiveness in terms of environment use.

All insights about the feasibility of a sustainability paradigm for the current generation are based on per capita data for representative individuals in each country, weighted according to the country's proportion of the total population in the study area. Moreover, the responses of sustainability conditions to the main changes in context (i.e., improved technology, modified consumption) are examined [45]. Finally, a representative individual for all countries from the current generation is compared with one from the future generation to describe inter-generational equity and efficiency.

2. Paradigms, concepts, and approaches

This section concisely defines the four sustainability paradigms, efficiency concepts, and equity approaches identified in Section 1.

A sustainability solution is Pareto-efficient if current generations in *each country* obtain greater welfare than in the status quo situation. In other words, there are no losers. A sustainability solution is Kaldor-Hicks efficient if current generations in *all countries combined* obtain greater welfare than in the status quo situation so that the losers can potentially receive compensation from the winners. A sustainability solution reduces inequalities between current generations in terms of consumption, environment use, or welfare level if the Gini index for one or more of these variables is smaller than the Gini index for the same variable in the status quo situation; it is then defined as Gini-equitable. A sustainability solution improves the conditions for the least advantaged current generation in terms of consumption, environment use, or welfare if the minimum value of one or more variables is larger than its value in the status quo situation; it is then defined as MaxMin-equitable.

The main assumptions behind weak sustainability (i.e., development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs) can be summarised as follows [33]: *needs* are used as the unit of measurement; the same weights are used for current and future generations; and there is *unconditional* substitution among current economic, social, and environmental forms of capital at both intra- and inter-generational levels. A sustainability solution is consistent with weak sustainability if it is at least Kaldor-Hicks efficient, and if it assumes a small aversion to inter- and intra-generational inequality.

A-growth is an ecological and economic strategy focused on indifference to or neutrality about the economic level and growth, which are considered non-robust and unreliable indicators of social welfare and progress [41,42]. It can be characterised as follows: *welfare* is used as the unit of measurement, as deduced from the aim of moving from wrong prices that result from the many neglected non-market transactions (e.g., informal activities and relationships) and the many unpriced environmental effects to right prices (i.e., prices that account for both non-market and unpriced values); *different* weights are used for current and future generations; and substitution between forms of capital is *possible*. A sustainability solution is consistent with a-growth if it is Gini-equitable for welfare, and if it assumes a small aversion to inter-generational and intra-generational inequality.

De-growth is an ecological and economic perspective based on achieving a socially sustainable and equitable reduction (and eventually stabilization) of the quantity of materials and energy that a society extracts, processes, transports, distributes, consumes, and returns to the environment as wastes [19,20]. It can be characterised as follows: *happiness* is the unit of measurement, with a priority on meeting the needs of the poorest individuals, as deduced from the aim of introducing a basic income; the *same* weight is assigned to current and future generations; and substitution among forms of capital is *acceptable*. A sustainability solution is consistent with a de-growth paradigm if it is MaxMin-equitable for welfare and if it assumes a large aversion to inter- and intra-generational inequality.

The main assumptions behind strong sustainability (i.e., a development that allows future generations to access the same amount of natural resources and the same environmental status as the current generation) can be summarised as follows [18]: *requirements* for some incommensurable categories as the unit of measurement; *possibly* assignment of different weights to current and future generations; and *no* substitution between current or future forms of capital, with physical and social capital considered to be complementary to natural capital. A sustainability solution is consistent with strong sustainability if it is Gini-equitable for consumption and environment use, and if it assumes a large aversion to inter- and intra-generational inequality.

Utilitarianism, in the version considered here [13], can be