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Increasing the rate of sustainable change: a call for a redefinition of the concept and the model for its implementation

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Abstract

Mankind is committed to taking sustainable pathways in search of a state of sustainability. Thirty years after the ''Limits to Growth'' published by the Club of Rome the world is still far from the equilibrium of sustainable development (SD). Technology is postponing the depletion of natural resources but is not solving the problem itself, either because the technology is itself not sustainable or because the application of it is being mismanaged. This article attempts to analyze the wide gap between the strategies drawn up and the effectiveness of the actions taken in implementing sustainability. The paper addresses the issue of whether or not mankind can make the right choices and has the right infrastructure of pathways to do so. In short, an answer is sought to the question, ''What are the prerequisites for the fastest rate of sustainable change?'' This question is tackled by the four authors. They start from critical arguments concerning the effectiveness of sustainable change, explain the terminology used in the article and identify the main factors for increasing the rate of sustainable change, which are then discussed in detail in each part of the text (EG). Then, each from a different starting point, they comment on self-organization (US), sustainable innovation and cultural regions (HK), global cooperation and regional resources (MB) and sustainable research by universities (EG). The individual contributions, when taken together, form a discussion of the crucial factors or prerequisites for sustainable change. It is concluded that only cooperation between regions and regional stakeholders can give sustainable change the driving force needed to overcome global (political) friction and ensure that it moves forward in equilibrium and at a constant rate. Specific measures are put forward to maximize awareness within and among regions.

Keywords: Sustainability; Self-organized processes; Wisdom and knowledge; Sustainable and cultural change; Role of universities global cooperation; Regional resources; Innovation; Technology; Regional and local societies

1. Introduction

It will require much more than internal change within companies and their management systems for industry to speed up the move away from unsustainability. The concepts of cleaner production, environmental management and even industrial ecology which emerged in 1982 are not enough to ensure a sustainable future. Sustainable consumption and cleaner production are steps in the right direction but will not accelerate the rate of sustainable change to the extent that is needed.

Sustainability as a word and as a concept is not a child of the 20th century as most of us tend to think. As far back as 1789 the American President, Thomas Jefferson, referred to it in a speech; in the late 19th century a German Forestry Code stipulated that the number of trees planted should not be smaller than the number cut down; in 1972 The Club of Rome published its first report, ''The Limits to Growth''; in 1987 the World Commission on Environment and Development (The Brundtland Commission) popularized the concept of sustainable development in the famous report ''Our

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Common Future''. In 1992 the Earth Summit, also known as the UN Conference on Environment and Development (UNCED), took place in Rio de Janeiro to reconcile worldwide economic development and protection of the environment. The Summit was the largest gathering of world leaders in history.

In policy terms the concept has been developed in recent years into the ''four capitals'' approach which, it is to be hoped, makes it easier to manage and implement. The extension into four capitals instead of three pillars separates out issues dealing with individuals (such as education, skills, innovation and entrepreneurship) from economic and social pillars [1]).

A strong as opposed to a weak approach to sustainability is characterized by a search for best practices which serve the development of all four capitals in contrast to making a trade-off between the capitals to maintain the total capital stock. Strong sustainability calls for maintenance of the stocks of all four capitals per capita. Weak sustainability requires only the total stock to be maintained (depleting natural capital is a trade-off for man-made capital accumulation in most cases). Thus an operational definition of sustainability can be formulated as follows: sustainability is the provision of services and benefits that increase human well-being without causing a decline in capital stocks per capita. Capital stocks (assets) provide a flow of goods and services which contribute to human well-being [1].

Assessing sustainability at any territorial level is difficult. Models and methods are often far removed from the challenge and the needs. The methodological difficulties arise mainly from problems in integrating the methods of scientific analysis of different research disciplines. In terms of overall integration and decision making frameworks the ideal is likely to remain out of reach in the sense that no one method can deal with all issues for all actors at all levels in a complex society [2]. World reports on the Millennium Declaration implementation process and also various environmental reports point to the considerable body of evidence that implementing sustainability globally has not been effective.

A similar evaluation of sustainability effectiveness (or rather the lack of it) emerges from the publications and reports of the Club of Rome. The scientific and knowledge based approach necessitates looking at the world system from the systemic perspective, analyzing it at different levels (see the World Problematique on the http://www.clubofrome.org website), drawing conclusions and formulating scenarios, as has been done with the Club of Rome's three reports, ''The Limits to Growth'' (LTG), ''Beyond the Limits'' (BTL) and ''The Limits to Growth, the 30-Year Update'' (LTG III) [3]. The last, LTG III, clearly suggests that a scientific approach is not enough. Scientific and knowledge based approaches to change have proved ineffective, judging by the fact that the warning of LTG (1972) is 30 years old. In LTG III (2004) the same team of MIT authors asserted that visioning, networking, truth-telling, learning and loving are needed to make the sustainability revolution work. Only some of these categories can be considered scientific [4].

Some researchers view sustainability as a messy and ill-defined concept [5]. The ideal model of sustainability is formulated vaguely in the Brundtland Report as well as in Agenda 21. The model does not present a recipe for action. Only through a generalized formulation with established concepts and paradigms has a high degree of international consensus been obtained. Yet this consensus comes at a price because the model left open how such consensus-seeking goals as ''future development must be such that economic, environmental, and social objectives are equally weighted'' ought to be pursued. The potential for manifold interpretation of the ideal model is significant. The words *sustainable*, *sustainability* and *development* lack consistent uniform definition, being container-type labels. Internal conflict is preprogrammed in the concept of sustainability and sustainable development. Even if we take the more precise definition formulated by Ms Gro Brundtland herself, which reads as follows: ''… Sustainable development does not imply absolute limits to growth and it is not a new name for environmental protection: it is a new concept of economic growth …. It is a process of change in which economic and fiscal policies, trade and foreign policies, energy, agricultural, and industrial policies all aim to induce development paths that are economically, socially and ecologically sustainable. It requires more equitable distribution and equal opportunities within and among nations'' [6], the problem remains unsolved and conflicts are clearly visible. Extrapolated consumption of primary energy products and raw materials in industrial countries with an increasing consumption in the developing countries promises obvious collapse. The third world can no longer become what the first world is and the first world can no longer remain as it is [7].

On their own more or better ideas will offer very little to enhance the use of sustainable development principles either now or in the future. In many cases ''advanced'' thinking has caused significant environmental damage [8]. Simply put, ''knowing more'' will be insufficient in helping us solve the sustainable development challenges this planet is facing. A shift is needed from knowledge (content and tools) to wisdom (aptness for conditions) in sustainability.

Most commonly SD is understood as positive change lasting over time which ensures that the well-being of the present generations does not lead to a decline in the well-being of the future generations. Thirty years after ''The Limits to Growth'' the world system was not, however, able to make a successful shift from the exploitative path of development to the new balance of sustainable development. It would seem wise to undertake the effort of looking for a more precise formulation of sustainability as a complex and self-dynamic process of change and from this new formulation find ways that show how the change can become more effective.

The contextuality of the concept of SD and local/regional interpretations makes the search for ''self-similar'' rather than ''identical'' solutions worldwide a matter of urgency. The global aspects of sustainability have to be understood well for local/regional self-similar solutions to be sought. Again, this cannot be effective if cultural dimensions are not considered. Effective change in the structure of the system

presupposes that the system is open to such change and is able to accept it. It is critical therefore to identify not only whether technology can solve most of the problems and threats to sustainability but also which cultural dimensions are necessary prerequisites for coping with change. Technology is arguably one of the most dominant factors in development in the 21st century. However, with the limited predictability of the future or even of our level of knowledge in the future, it is very difficult to forecast precisely which technological solutions will contribute most to sustainability worldwide in the longer run of 25–75 years.

This leads to a further significant question. Isn't there a need for a *new type of technology* characterized by a more symbiotic metabolism with nature and which is more dialog-orientated, adaptive and based on partnership functions with humans? Building scenarios and looking for best possible remedies to problems locally/regionally according to a scenario may only slightly decrease the risks associated with unsustainable practices. Visualization might raise ecological awareness and help in decision-making processes. Research and education for sustainability require study of the real world from the perspective of many different academic disciplines. Nurturing interdisciplinary and multidisciplinary thinking and learning should become the main guideline for institutions of higher education worldwide. Technology, especially a new type of technology, can be a tool in such processes. Addressing all these issues correctly may bring about a breakthrough on our pathway to a better and more sustainable world. The progress from knowledge to wisdom in achieving sustainability is the key message of this article.

In the interests of clarity, the expressions "wisdom", "knowledge", "sustainable change" and "cultural change" in the context of sustainability are defined and understood by the authors as follows:

Knowledge is defined as information received and understood as processed and analyzed data answering the basic question of W H A T. This knowledge has different levels of reference. For sustainability the global level of knowledge is the most important.

Wisdom is understood as consciousness of the threats and opportunities particular to our local and regional societies. This results from our knowing and understanding the state of the Earth or the processes occurring in it and our ability to change the inherited scale of values. Wisdom means the will and readiness of local and regional societies to alter present behaviors and values. In this sense it tells us H O W to proceed, especially at these levels.

Sustainable change is the change in structure or its interconnections which promises a step forward to the equilibrium of sustainable development. It has to be emphasized, however, that in trying to bring about this change we face a number of difficulties arising from the limitations of our current knowledge concerning systems theory, the self-dynamics of the systems and the availability of reliable scenarios of future developments in technology or in political or social systems.

Cultural change is part of sustainable change. It determines the rate of sustainable change because it is the system of values, basic principles and beliefs of the local and/or regional societies which control the rate of societal change, the main driving force for either rejecting or accepting a sustainable solution.

2. The relationship between sustainability and complex dynamic development

With the transition into the 21st century a new quality of consolidation has become noticeable in economic, ecological, social, technological and cultural processes, both locally and globally. In short, the globalized "aggregate state" of problems is attaining a new quality of dynamic complexity which can no longer be mastered adequately using traditional problem-solving patterns.

Yet at this time of upheaval, of instability, crises and insecurity the search for corrective solutions is in danger of being submerged under a deluge of information. How therefore can knowledge oriented to *sustainable development* be managed or stable problem-solving patterns be drawn up that on the one hand promise sustainable longer-term attributes and yet on the other have equally dynamic, adaptive and verifiable properties? It is assumed that resolving this is an important focus of this section.

Two very promising approaches to transcending the tradition of linear-mechanistic or simple causal methods of thought and behavior can be found, firstly, in the surrounding discussion on SD and secondly in the field of research into the non-linear complex dynamic processes of *self-organization* and *evolution strategies* (for references see [9–11]).

The guiding principle of sustainability is currently meeting with a significant response in society, politics, business and ecology, whether within the framework of Agenda 21 processes, in regional development, or in the sustainability reports of businesses.

In parallel, and largely unconnected with the sustainability discussion, a wide-ranging discussion has been taking place for more than two decades over non-linear complex systems: whether in research into the "edge of chaos", in the context of business project management or in evolutionary optimization strategies. Complex adaptive systems are usually drawn upon to simulate and find solutions to complex process patterns to assist in the implementation of the evolutionary optimization strategies.

The underlying idea of the project presented here is to link problem-solving patterns already existing in the sphere of sustainability with those of basic and applied research on complexity, localized operating conditions and evolution, solidify them, and develop them further. A newly defined strategy/concept on sustainability should be one that helps to ease sustainable thought and realize problem-solving actions, by means of complex adaptive systems.

2.1. Approach 1: current SD theory

Current discussion about the concept of SD focuses primarily on *generational equity* (SD retains the fundamentals on

which future generations can make their own development choices); *holism* (this demands equal weightings for economic stability, ecological compatibility and social equilibrium); *globalization* (including the repercussions of ones' own actions on people in other regions); as well as *participation* (SD should be continuously reviewed afresh by means of social dialog). It is therefore a systemic process which, taking into consideration the complex interaction and feedback, aims at a workable balance among ecological, economic and social interests.

In the best case (maximal solution) the goal is to achieve win-win solutions. The goal of SD is *not* first and foremost *compromise*, but an *optimum* of ecological, economic and social interests. A minimal solution, on the other hand, would be based on reciprocity among the different interests.

In order to actualize sustainable solutions, a set of indicators for the relevant economic, ecological and social interests is taken, observed initially individually, and then in aggregate. Their stability, quality and longer-term development dynamic is analyzed in social dialogue among the major participants.

2.2. Approach 2: SD theory linking self-organization

SD processes are non-linear, complex dynamic processes which demand *new kinds of communication* between humanity, nature and technology.

Initially as a sub-section, person-to-person communication is significant as a complex social dialog out of which both organization structures and behaviors emerge. In addition, the complex relationship between man and nature continues to be of central importance for life, for ecology on Earth. The communicative relationship between man and technology is taking on an increasingly key role - in the form of new media as well as in relation to computer-aided cognition or the formation of models of complex processes.

In the following pages, the totality of these three communication processes will be described as "*complex communication*". These processes are relatively emergent, in that new qualities appear unexpectedly that are not explicable through their characteristics or in relation to the elements involved but through a specific *self-organizing process dynamic* in each case.

"Self-organization" and "emergence" are closely connected: in open systems, self-organization is the spontaneous appearance of new structures and modes of behavior away from equilibrium and characterized by internal feedback loops and non-linear processes. The structures that arise are more than the sum of their parts. This "more"—the new quality—emerges through the prevailing kind of cross-linkage and gives rise to a high degree of complexity, made up of many simple components. Thus the individual grows out of itself. Examples of this are biological evolution, social groups, the human brain or complex adaptive technologies such as neuronal networks.

In this way global attributes grow out of this self-organization of complex, dynamic systems in the form of stable patterns or states of order, which arise out of the aggregate behavior of individuals/elements or relatively simple subprocesses. Global surface *complexity* therefore emanates under specific conditions from an underlying bottom (local) *simplicity*. But it is not possible to simplify the global complexity by reducing the top down to the bottom elements. Global SD could therefore be modeled as a bottom-up process from "local" to "global" under specific ecological, economic and social boundaries all over the world, a theme explored further in this paper.

In its deeper meaning SD can also be interpreted as a *complex communication process*, in which the "sub-systems" of economy (man), ecology (nature) and society (technology) act integratively and produce stable, lasting solutions. SD would in this way allow itself to be *modeled* as a *relatively stable pattern* within a self-organizing process dynamic. Thus, with the aid of a complex interaction process within and between the economy, ecology and society sub-systems, a compatible total system would be created which would function on the whole as a "complex adaptive system" [12].

Since the total system should fundamentally be capable of self-organization or evolution, the essence here is a co-evolutionary model among humans, nature and technology, with whose help SD would be modeled and implemented.

2.3. Approach 3: SD theory and evolutionary stable systems

With the help of game theory as well as evolutionary, generalized models, the win-win approach can be taken further. In game theory a "Nash strategy" arises for each player when they achieve the greatest possible advantage for themselves, provided that all the other players are following their own Nash strategies. In this case there is a "Nash equilibrium".

A Nash equilibrium can be generalized as an "Evolutionary Stable System" (ESS) in which the players consist of every single genotype, thus displaying all types and behaviors, and where the greatest possible advantage is in scaling a "fitness peak". In an ESS no player changes their Nash strategy as long as the other players are following their Nash strategies. Figuratively speaking, all participants are at a local "fitness peak". If a species/player diverges from its/his strategy, the fitness of that species/player would diminish. A *sustainable* strategy ought to achieve Nash equilibrium if possible as a minimal solution or, alternatively, an evolutionary strategy but this would *not be* the optimum that is possible, as the highest median fitness is not yet achieved. A complex adaptive system within an *ordered* ESS area is too rigid to get away from the relatively low-level, local fitness peaks. Contrarily, chaotic, disorderly behavior achieves much too modest overall fitness, since no fitness peak will be arrived at [13, ch. 10].

The *optimal result* will be achieved where a specific fitness (i.e. the edge of chaos) reaches the intermediate area or *transition phase between order and chaos*. This understanding is congruent with a universal meaning of the "Evolution Window"—evolutive progress is only guaranteed within a narrow area of the mutation step size, it only attains optimal speed within a slim band [14]. An illustrative example of this concept from social action might be: anarchists and firebrands

widely overshoot the target and progress speed is negative (advance then regress); yet amongst ultraconservatives and the hyper-scrupulous, the speed of progress is around nil (stagnation). Deciding on the right mutation (change in behavior) step size is an art—for managers, politicians and engineers alike and is equally critical for SD initiatives.

Co-evolution of complex adaptive systems (discernible for both natural and artificial model systems) is self-evolving through autocatalysis or self-organized processes—right up to *the edge of chaos*. In general the edge of chaos can be shown as the *balance* between supra-critical chaotic regimes and sub-critical orderly states (see Fig. 1).

The edge of chaos represents an optimum in so far as the median fitness for the conditions is the highest and the extinction rate is the lowest, although the extinction rate obeys a power law. System states on the edge of chaos are also described as at a *self-organized criticality*, where unforeseeable small or large waves or avalanche-like changes can be triggered by disturbances of small magnitude. The average frequency of a given size of change is inversely proportional to the power of its size so that large changes are rare, while small ones are frequent (power law). A state of that kind obviously has universal significance for complex dynamic self-organization processes, particularly for the behavior of *living* systems.

The state of self-organized criticality is determined by a *weak chaotic attractor state* (strange attractor). Chaotic attractors, and thus the state of self-organized criticality, are fractals, in other words their characteristic spatial structures recur perpetually in all dimensions, as a pattern within a pattern.

A circle is complete here: fractals can be observed everywhere where contradictory or opposite conditions are met in a system, for example as an optimization or mini-max problem. Evolution solves the problem of how a living system can maximize gaseous exchange with its environment using the *minimum* of matter with a fractal ''structure'', for instance of a lung or a tree, where a partial detail reveals a pattern similar to that of the whole.

This characteristic is also described as self-similarity or scale freedom. Thus self-organized criticality is a self-similar dynamic. Complex adaptive, self-organizing development processes therefore have a tendency through learning and ''the evolution of co-evolution'' to move at the edge of chaos, into a critical equilibrium state, into ''*dynamic stability of creative change*''. Therefore a *chaotic attractor state* or that of *self-organized criticality* does appear to be a suitable *model for sustainable solutions*, since here stability combines with creativity and dynamic self-correction.

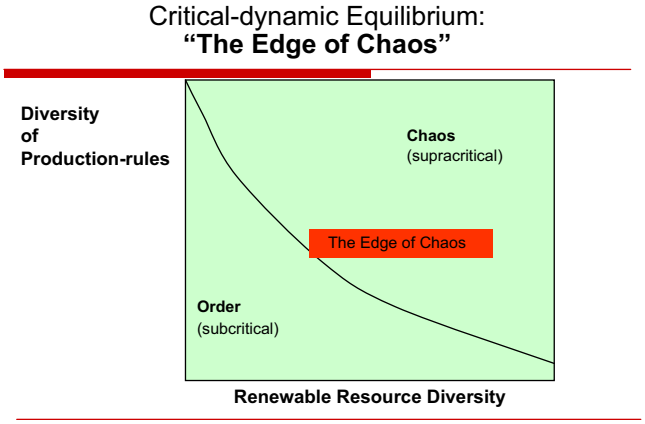

Fig. 1. Critical-dynamic equilibrium [13].

In our case, evolution of co-evolution of the sub-systems of humanity, nature and technology, or economy, ecology and society, would be regarded as a compatible or—better—an optimal and adaptive complete system.

Hence the principles of self-organization, edge of chaos and evolution of co-evolution could be used to model and implement an underlying concept for SD. The *fundamental model approach* in this context is therefore formulated as follows: the overall concept of sustainability is defined as the balance between (supra-critical) innovation and (sub-critical) durability. Thus the critical equilibrium state (''edge of chaos'') is defined as the dynamic stability of creative change (see Fig. 2).

It is also necessary to include *evolution of cooperation*. Conditions have to be fostered that positively support constructive communication and interdisciplinary cooperation by the participants and avoid destructive or non-compliant patterns of behavior. It is particularly *the optimal interaction* of scientific-technical thinking on one side and humanistic-cultural thinking on the other that is of great significance. These ''two cultures'' of thought (C.P. Snow) must be brought together at last.

Sustainability strategies therefore require constructiveness, communication and cooperation. They demand motivation and sensibility for problem solutions, yet may be vulnerable and react sensitively to destructive disturbances—a strength and a weakness. That is why conditions and opportunities for cooperation as well as recommendations for encouraging cooperation should be present.

The self-similarity of the patterns and properties of chaotic attractors suggests a working hypothesis that *local and global sustainability processes can be modeled as self-similar*.

This might mean that the motto of the sustainability movement, ''Think globally, act locally'', could experience a deeper realization (see also general references for the background [13:p. 289–298,15]).

3. Sustainability and society

Global sustainability is concerned about simple things like polluting air, water, soil and the availability of energy carriers. Regional/local sustainability should be the cornerstone of global sustainability. A region can very well deal with the input of clean air, water and high quality primary energy and the output of its degradation products of contaminated air, water and low quality energy (heat) in a sustainable way. This requires relationships with other regions and the idea behind this is *Regional Ecology*. The question is: how can regions cooperate along a sustainable pathway?

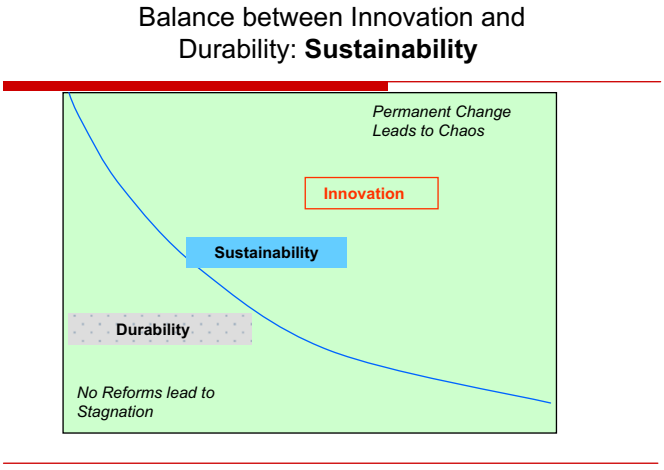

Fig. 2. Sustainability as a balance between innovation and durability.

In the first paragraph, the number of human regions on Earth is estimated by a novel method independent of social, political, historical and other traditional classification methods. A number of cultural dimensions are explored to characterize them. In the following paragraph there is an attempt to link sustainable innovations with regions and in the final paragraph ideas are given to assign regions the role in global society which they should have: serving the well-being of humans.

3.1. Countries, territories and regions

The 231 countries and territories are ranked with increasing land area in Fig. 3, which also shows their populations.

A first estimate of the number of regions within these 231 countries/territories can be obtained by comparing the population of countries of adjacent land areas as exemplified in Table 1.

Application of the Table 1 method to all 231 countries/territories from Fig. 3 gives 20 ± 10 regions per country/territory.

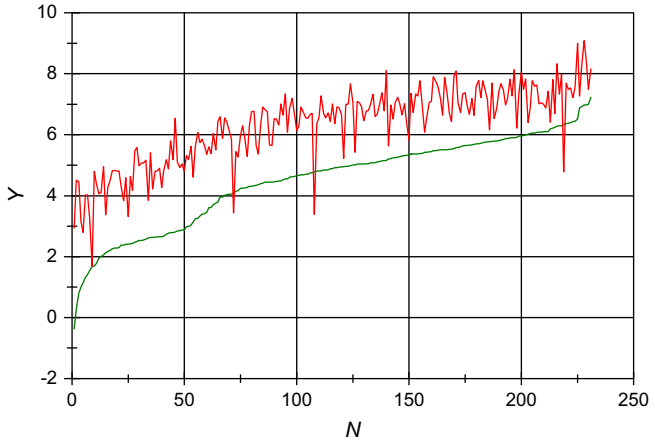

Fig. 3. The population and land area of the 231 countries and territories ranked with increasing land area. N = country/territory number and 10^Y = land area in km^2 (lower line) and associated population (upper line). (Data countries/territories: http://www.stats.demon.nl/world/gen.htm, source: World Fact Book 1999, CIA.)

The total number of regions in the world is, according to this novel method, more than 2000, less than 7000 and on average about 4500. The task is to develop tools and means to find and tag these regions as identifiable societies.

3.2. Cultural dimensions

Hofstede [16] describes countries in terms of five cultural dimensions, indexing each of them so that, in principle, an infinite number of countries can be characterized. The five cultural elements are (A): long term orientation (LTO), (B) power distance (PDI); (C) uncertainty avoidance (UAI); (D) individuality (IDV) and (E) masculinity (MAS). In this contribution the Hofstede classification is simplified. The scores for the five elements are ranked from high to low. This gives a finite number of $5! = 120$ possible sequences. This sequence can be further simplified by just looking at the highest scoring cultural element. Fig. 4 gives a histogram based upon a table given by Claes and Gerritsen [17] showing the most important cultural dimensions for 33 countries.

With 120 possible sequences and 231 countries/territories there will be countries/territories with the same sequence. By way of a snapshot, of the 33 countries in Fig. 4, 24 different sequences of Hofstede's five cultural dimensions have been generated. Sequences occurring more than once are: BAEDC (India and Singapore), CDBEA (Belgium, Czech Republic and France), CBEDA (Pakistan and Poland), DCEBA (Canada, USA, Germany and Australia) and ECDAB (Austria and Hungary).

Claes and Gerritsen [17] also provide information about regional sequences (see Table 2).

The impression is that differences in culture are subtle and that the rate of cultural change is slow. China and Hong Kong have the same sequence in spite of a century of different rule, the correlation being that both stayed in their environment. A language membrane around a region can affect the sequence, only secondary in the case of people emigrating to Canada. The culture gap between the original population of Australia and immigrants is easily explained: the immigrants are of the D-type and the original population of the C-type in this case.

To allow a unique description of 4500 regions in terms of sequences needs typically seven cultural dimensions ($7! = 5040$). Adopting the Hofstede five means two other cultural dimensions to find or choose.

3.3. Regional sustainable innovations

Change cannot exceed cultural change. (To verify this needs the active involvement of the community to see what is the acceptable rate of change for the members.) So from the point of view of country regions, change imposed by other regions or change generated within the region itself is not sustainable a priori. Sustainable change is a regional issue running at the same rate as cultural change.

Innovations are vehicles to improve directly the life of inventors, the industry and its clients. Table 3 lists the top five and bottom five sectors in the Dutch economy.

Table 1
Method for calculating the number of regions

Rank area	Continent	Country/territory	Capital city	km^2	Population	Population forwards	Ratio backwards
162	ER	Italy	Rome	301230	56735130		1.47
163	ER	Poland	Warsaw	312683	38608929	0.68	2.44
164	AF	Cote d'Ivoire	Yamaussoukro	322460	15818068	0.41	3.56
165	ER	Norway	Oslo	324220	4438547	0.28	0.06
166	AS	Vietnam	Hanoi	329560	77311210	17.42	3.62
167	AS	Malaysia	Kuala Lumpur	329750	21376066	0.28	4.14
168	ER	Finland	Helsinki	337030	5158372	0.24	1.90
169	AF	Congo, Republic of	Brazzaville	342000	2716814	0.53	0.03
170	ER	Germany	Berlin	356910	82087361	30.21	0.65
171	AS	Japan	Tokyo	377835	126182077	1.54	
Average						5.7	2.0
Standard deviation						3.6	0.5

Source: Own calculations. First the average and standard deviation of forward (direction of increasing land area) and backward (direction of decreasing land area) population ratio are calculated. From these two averages and standard deviations an overall average and standard deviation are calculated: average 4, standard deviation 2. The number of regions when only these 10 countries are considered is then between 2 and 6, averaging 4.

Sustainable innovations ask for a broader perspective. They require, at least, no reduction in the potential of the cultural and natural environment. Negative aspects in employment should be compensated by new industries.

Regional sustainable innovations require more. It will be noticed that ranks 54–58 are "local range" industries with hardly any inter-regional aspects. From within the top five innovative sectors, innovations are born out of the pressure of an economy of scale favoring low labor cost countries. These innovations are promoting volatility in society, focusing on fashionable products and niche markets, but not supporting and deepening regional culture.

Regional sustainable innovations aim in the first place at their own region. Regions sharing the same sequence of cultural dimensions are the first candidates to export self-similar sustainable innovation.

An intriguing challenge is to identify sequence codes for particular sustainable innovations. One way is to look at sequences not yet found, as regional sustainability is new. There are 120 possibilities and 24 are known, so potentially there are 96 to be identified. The problem is not so much how to find them all, but how to find the best of the 96 needles hidden in the haystack, deducing them from first principles. A long-term orientation (= A) is necessary in sustainability issues. Creativity relates to individuality (= D), so the sequence should start with AD. It should end with E (= MAS), since holistic approaches are feminine not masculine. Power distance (= B) structures invite uncertainty avoidance (= C) behavior, so that the sequence for sustainable innovations is probably ADBCE. This Shangri La sequence differs from the 24 recorded ones, satisfying the notion that the sequence to look for has not yet been found. This conclusion also goes for the recorded sequences of 33 countries lacking measurement of A. The sequence DBCE is lacking too. But of course the interest is in country regions not country averages. Each country may still have its own Shangri La sequence.

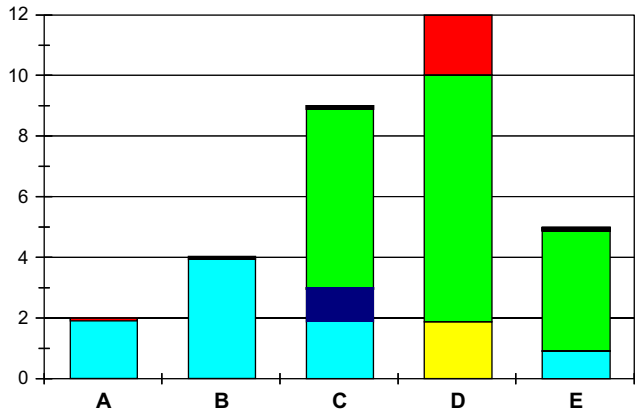

Fig. 4. Thirty-three countries of five continents ranked according to their highest score cultural dimension A (= LTO), B (= PDI), C (= UAI), D (= IDV) and E (= MAS). Countries from different continents are represented by different shading. Figure based upon the data of Claes and Gerritsen [17].

3.4. Regional cooperation

A region has an internal structure enveloped by a membrane separating it from other regions. Its government is ultimately responsible for the internal increase in happiness of its population in a certain time frame.

One of the tools the government has is the exchange of products with other regions. As each region has a limited production capacity, so too its exchange potential is limited. Its degree of freedom is measured by surplus output and the choice of goods to be imported into the region. Sustainable constraints are: (1) consumption of regionally made products

Table 2
Sequences of countries and country regions

Continent	Country/country region	A	B	C	D	E	Sequence
AO	Australia	31	36	51	90	61	DECBA
	Australia aboriginals	−10	80	128	89	22	CDBEA
NA	Canada	23	39	48	80	52	DECBA
	Canada French	30	54	60	73	45	DCBEA
AS	China	118	80	30	20	66	ABECD
	Hong Kong	96	68	29	25	57	ABECD

Source: Claes and Gerritsen [17].

Table 3
Top five and bottom five innovative sectors in the Netherlands

Rank	Sector	Rank	Sector
1	Chemical, plastics and rubber industry	54	Retail of clothes, shoes and textiles
2	Research and development industry	55	Personal transport
3	Computer services and ICT	56	Road, soil and water works
4	Tobacco and Drinks industry	57	Cattle-raising industry
5	Wholesale trade investment goods	58	Market and street trade

Source: National Statistics.

within the region; (2) production by a regional workforce; (3) production in regionally owned facilities. New products are usually more complex, so regions typically have to cooperate inter-regionally in production chains/networks.

Products evolve, others become extinct and completely new ones appear on the scene. In general new products are more complex than older ones. This puts stress on the diversity of products made in a given region. Solutions for a given regional size are to decrease product diversity or become part of an inter-regional chain (clusters). The latter form of production can be organized by a multi-regional enterprise, but this is outside a sustainable framework as the workforce in the participating regions no longer has influence on the end product. Hence regional cooperation (symbiosis) should precede production by enterprises operating inter-regionally.

New knowledge and applications should be generated by universities, tried out in the closed quarters of SMEs and eventually exported by large enterprises (LEs) to other cooperating regions. Kleizen [18] calculates that inter-regional cooperation in today's Europe should involve about 16 million people in order to generate enough mass for one university. This university, dedicating research work to its founding regions, may very well choose to take up residence in the region with the code ADBCE.

3.5. Concluding remarks

A new method is presented for estimating the number of regions in the World on the basis of the population ratio of countries/territories with adjacent larger and smaller land areas. The Hofstede five culture indices are reduced to a sequence in order to have a quick country scan. The scan also shows explainable differences between countries and country regions. An extension of the Hofstede five with two other dimensions will be sufficient to reveal more refined differences. It is argued that, in terms of the Hofstede five, the sequence ADBCE decodes for regional sustainable innovations. The evolution of products invites regional cooperation with a central role to be played by the ADBCE region. Regional cooperation will not be the end of development; it may develop in worldwide regional cooperation. The alternative is strongly interacting groups of regions developing not only smart products but also smart money [19], money that—among other new functions—promotes regional interest. Wisdom guided by the heart will show the sustainable pathway to follow.

4. Transition to sustainability

Knowing more will be insufficient in helping to solve the sustainable development challenges this planet is facing. When ideas and theories move from the conceptual realm into the physical real-world setting, wisdom is the consistently ignored element in the application phase. The aptness of the solution to the proposed site seems to be ignored as an element in the process of SD implementation. Instead "higher quality thinking" or "better and smarter ideas" take precedence and prominence in the process of selecting the right solution [20].

The most significant issue in a given situation can be assessed with a basic and oft ignored question: "Is this idea and suggested process holistically suitable to the environment in which we are proposing that it be used?" This question seems to be ignored, with many SD initiatives opting for "proven applications" rather then designing self-similar and adaptive solutions. The issue of transition to sustainability is analyzed here using the context of optimization of the use of water resources.

4.1. Sustainable development and the "Global" currency map

In "A Drop in the Ocean for Foresight Practitioners" [21] the "Global currency unit" (GCU) was introduced. A "Global" is the equivalent of one liter of fresh water. As all goods and services rely on water at some stage in the production cycle, all trade exchanges can be viewed as merely shifting water in its various end states. In doing this we recognize that the only universal currency unit we have on this planet is fresh water and trade exchanges can be viewed not by some arbitrary fiscal currency value but by how many "Globals" would be exchanged in both the production and delivery of a product or service. The Global currency map (GCM) is a tool that assesses the quantity of Globals available to a country (indicating geographical and topographical bias) combined with a broad take on GDP figures. The GCM is shown in Fig. 5.

If we take the GCM and insert examples of countries that "fit" within the various GCM zones we are presented with an assessment along the lines shown in Fig. 6. Please note that this is not definitive of any or all countries.

For those interested in SD it should be immediately apparent that of those countries listed in the example above each faces different SD challenges and that ideally the SD strategies

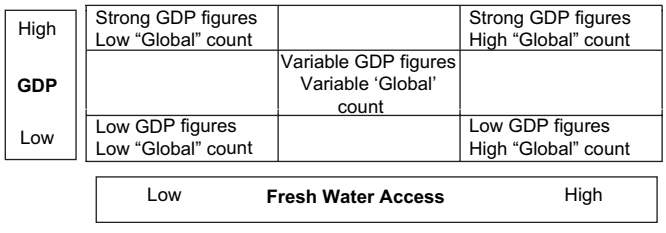

Fig. 5. The Global currency map (GCM).

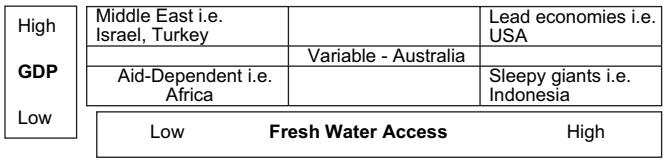

Fig. 6. The Global currency map (GCM) in its geographical context.

chosen should reflect the natural capacity of the geographic zone as well as the technical and financial capacity available to it. An overview of strategies likely to be ''favored'' is presented below.

And therein lies our first step in moving from knowledge to wisdom: the SD strategies applicable to one part of the GCM cannot be assumed to be applicable for countries positioned in other parts of the GCM. Put more succinctly, a highly technical and expensive idea taken from a developed nation would be inappropriate in an area lacking the human and financial resources required for implementation. The best strategic choices will be those that utilize existing capabilities of the available people, taking into account the resources that can be called upon both to maintain and to develop the idea further. In this way, we take into consideration the ''aptness'' aspect of SD and this leads to wisdom in the choices made.

4.2. Life conditions and strategic choices

Within a sustainable development context, ''life conditions'' will emerge from the various economic, social, geographical and environmental assets and challenges the society faces. In considering the ''aptness'' of a sustainable development initiative (appropriateness of the idea to the environmental conditions) we begin to understand that different societies tackle their SD problems in different ways. In fact, as a society solves one level of the SD challenge, it will typically face another more complex one and until it solves that problem cannot be concerned with others beyond it.

Here we face the paradox of choice. SD urges us to think in the longer term in the choices we make. Whilst a reasonable call for some it ignores the realities of others whose very existence demands that they solve the present day crisis facing them BEFORE they can begin entertaining thoughts of tomorrow.

Taking the idea of ''water'' and the differing contexts available to societies positioned in differing zones of the GCM, we can see that for societies with a high GDP and high water availability, water apart from standard use can also be a resource for entertainment or luxury. This differs greatly from countries in the lower right corner where water is abundant but income levels are typically low. Water is seen as a transportation method, disposal method or something that feeds the forests being ravaged in order to generate income or food. In the lower left corner water is about life itself—both sustaining and denying life. And in the upper left corner water is a scarce resource and the focus is on technology aimed at providing fresh water for the masses and for industrial growth.

How realistic, then, is the call by developed nations for developing nations to operate in the very same way (open access trade, resource heavy equipment, machinery and tools, energy hungry buildings and transport infrastructure) when the actual demands for sustainable development hinge on solving the most basic of issues first—survival? In terms of societal values we have seen current debate on approaches to sustainability as a clash between developing versus developed nations. In this light the *aspirational* desire of developing nations to improve lifestyle is held against the developed nations' desire to *maintain* their existing lifestyle. For nations in crisis the desire if far more stark (survival) and the clash of values between poor nations and rich ones can be stated as ''*life versus lifestyle*''.

Again we can turn to the GCM to assess the general society focus, likely barriers and likely strategies (Fig. 7).

In order to enable a transition to sustainability around the world, wisdom demands that we focus not just on idea generation but on aptness and adaptiveness to the current need. To a large extent this ties us back to a core question posed by Molly Harris-Olsen, who suggests that a key starting point is to answer the question ''*just what exactly are we trying to sustain?*'' [22].

Once we answer that fundamental question, possibilities for action based on realistic expectations of success begin to emerge. What we also begin to address are the cultural dimensions and regional issues that influence the reliance on particular strategic approaches and again discover that a ''one size fits all'', top-down approach will be insufficient in tackling local/regional sustainable development issues over the long term. Others have suggested that the GCM could also apply to energy and other resources rather than just water and this could also be a valid way of applying the GCM approach. Let us take one water example as a case in point.

A key asset available to emerging giants such as Indonesia is an abundance of forest timber and huge demand around the world. Timber is one of Indonesia's fundamental assets and the societal challenge that Indonesia is trying to solve is improved living conditions for its vast population. In order to fund those improvements Indonesia uses a key resource (timber) to generate income to provide cash flows used for food and other developmental needs (note: improved government controls over logging would deliver greater returns for Indonesia than what it now gains from the *ad hoc* approach to logging permits). The asset is greatly assisted by an abundance of water and good soil conditions.

Yet opponents of logging (often citizens from the developed nations) protest that logging is having a negative impact on the ecosystems of Indonesia and the planet as a whole. This is true, but such a position misses the point: Indonesia has a right to find ways for its society to improve the living standards of its population. The issue really is not logging per se; it is about income generation. The fundamental SD challenge for protesters is accepting Indonesia's (and other logging nations') right to generate income whilst simultaneously allowing trees to remain in place. The obvious question is 'HOW?' How might Indonesia generate an income WITHOUT ravaging the forests that are simultaneously an equally vital asset to both Indonesia and the rest of the world?

GCM Rating	Societal Focus	Typical Strategies	Resistance to
High Water High GDP	Luxury goods & entertainment	Technology driven; government oversight; carbon energy sources	Tax penalties; personal restrictions; legislative intervention
High Water; Low GDP	Economic growth; food production	Forest clearing; tax incentives for multinational firms	Overseas intervention; restrictive SD policies
Low Water; High GDP	Efficiencies in production; water rights;	Importing "technological silver bullets" or local R&D incentives	Cross border complaints; slowing of economic development
Low Water; Low GDP	Survival; disease; famine	Aid handouts; ancestral approaches; high birth rates; "magnet" cities	Lack of consultation; inflexible business rules imposed from "beyond"

Fig. 7. GCM confronted with the general society focus, likely barriers and likely strategies.

One solution could be the introduction of an ''oxygen credit'' system in counterbalance to the carbon credits scheme [20]. The existing ''carbon credits'' as a system is actually a permission slip for countries and their industries to pollute the globe. Whilst it has the potential to help, the current system is really geared to assisting already developed nations and does little to assist developing nations. To counterbalance the inequities, the ''oxygen credit'' system would pay nations like Indonesia for NOT logging their forests and for that country to act as the ''global lungs'' for the planet. Countries with net carbon excess would be required to pay a levy to those nations with net oxygen excess. In this example the abundance of water available to Indonesia can be used to grow more forests, helping offset the climate impacts of more developed nations paying the oxygen credits levy.

This idea would give poorer and developing nations with high forestry assets income for providing a net positive outcome to the planet in a way that maximizes benefits for both the developing nation and the developed nation. Merely chanting ''stop logging'' is an insufficient and unrealistic approach that ignores the ''aptness'' (wisdom) of sustainable development choice. This process would also make sustainable forestry practices more attractive by increasing the asset value of plantation timbers as they grow and perhaps improve viability of plantation and forests regardless of their location.

It is clear that this is just an extrapolation of an idea to expose the different lenses through which the SD initiative might be assessed. A brief anecdote taken from Kurt Seeman [23], who works with indigenous communities in Australia, highlights the challenge of ignoring ''aptness'' in pursuing sustainable development initiatives. Working for the Desert CRC, he tells of ''big city'' engineers building an outback toilet block using advanced technology in its design with a completely dysfunctional outcome because a critical factor (the type of toilet paper) was not considered for the local conditions. As Seeman states, ''throwing more technology at a non technical problem doesn't work'' [24].

4.3. Enabling the transition

SD concepts (be they government, university, community or business initiated) must move beyond ''good ideas'' to include the critical ''aptness'' aspect, for it is this that moves us from knowledge to wisdom. Identification of a regional Shangri La code is another way of ensuring that wisdom, and not just knowledge, is brought to the sustainable development initiative.

Governments should utilize tax incentives to encourage investment in SD ideas and they must use legislative penalties to force movement where personal, community or business standards are slow to change from negative behaviors.

Developed nations might also enable developing nations with the transition through R&D support and proven clean technologies. In Australia, assessment by Greenpeace suggests that the nation has available clean technologies skill sets [25] and these may be transferable given suitable matching of the technologies to other regions. Efforts by the Australian Coal Industry in pursuing cleaner technology for coal production and use [26] aim to recognize the realities of the use of coal as a viable energy source. Off the back of such developments, the Australian Government has announced a partnership at the recent Asia-Pacific Partnership on Clean Development and Climate with the aim of assisting in further development of the transfer of clean technologies to developing nations [27,28].

Technology can be a huge asset, but only where injection of a technology does not then tie the local community to importing supporting infrastructure or materials to maintain the technology. This process is self-defeating and unsustainable.

Community groups will typically be better placed than governments to fix local problems. The challenge is to ensure community groups understand that they are part of a much larger picture and gaining widespread and governmental support means an acceptance that they may not be able to get everything they desire if what they want impacts negatively on other sectors of the community.

Businesses should be allowed to profit but not at the expense of future generations. R&D incentives for development of appropriate SD initiatives can be paid for using taxation levied against unsustainable production methods and products that emerge from those methods.

4.4. Summary

Knowledge alone will not deliver the results we require, for it is wisdom that ensures that the solutions we design are ''apt'' or adaptive (self-similar) for the local and/or regional situation. Other parts of this paper show that aptness

(self-similarity) will consider not only the level of technology appropriate to the challenge and the available resources, but will also include the thinking of people at all levels in creating the most appropriate solution. For some that will mean the local village should control and determine what solutions are appropriate while for others it will require the efforts of the ''head office'' to dictate the actions that must be taken. Significantly, our focus must be on meeting the urgent needs presented by current problems as well as on thinking about future developments.

The Global currency map message is straightforward. There are inherent geographical, topographical and resource inequities in the world in which we live. SD initiatives designed for local conditions using knowledge from around the globe (self-similar solutions) will enable each community to develop wisdom and solve its most urgent challenges and begin building a capacity to be able to solve the next challenges that emerge. If we continue to ''inject'' inappropriate ideas taken from one society into a society with drastically different life conditions and cultural dimensions, we will continue to waste valuable time and resources chasing solutions that never come.

Generating ''apt'' sustainable development strategies requires us to question the very assumptions that have brought us to a critical time in humanity's developmental path. Unless we do so we cannot gain the level of wisdom required to navigate the most simple of futures, let alone the complexity of the future now before us. The issue now is for us to identify where and how this move from knowledge to wisdom can be generated.

5. The role of universities and science in the transition to sustainability

Institutions of higher education have a crucial role to play in education for SD. They influence and shape the mind sets of learners, which are of course also influenced by other factors such as cultural background, type of personality and individual inner drive to act and/or resonate. They are in a position to incorporate the cultural and values mix of their faculty and students to design self-similar and ''apt'' solutions to the SD challenges faced by the world. Individual perspectives of perceiving reality and handling it differ considerably, although taking thought together for a sustainable future requires structuring a common approach at least in the basics. This difficult task has to be undertaken by education systems at university level.

Our thinking about and perception of reality and the world is constructed in accordance with at least four models. Change in the globalization driven model is subject to such factors as financial stress, stock exchange failure or success, competitors, markets, fiscality and regulation, while in the world mind model driven by regionalization the change occurs by education, freedom of information, emancipation, leadership, technical breakthroughs, oil shortage, European alliances and the internet [24].

As a result of the differences in mental models (Fig. 8), we are far from adopting a single approach in our thinking about the global future. Again, it is the role of institutions of higher education (IHEs), among others forces, to influence the mind sets of students [4].

How might universities influence their students' mind sets in such a way that graduates bring more active commitment to the processes of regional SD (RSD) and live in a more sustainable and modest way, thus demonstrating their human qualities and ethical self-awareness?

How can universities respond to the challenge of being more involved in RSD? How can universities themselves become working models for sustainable management? The numerous reports on education at higher level available on the internet, most often under the heading ''Education for the 20th century'' or something similar, do not leave much hope that change will be rapid and quickly visible. IHEs are traditional organizations with a relatively low level of change potential and very defensive when it comes to limits on their freedom of any kind. They are in effect evolutionary stable systems within ''ordered'' states and their capacity for sustainable change is restricted as a result of the principle of ''path dependence''.

The challenges (or life conditions) of contemporary development will, however, make most academic institutions rethink their strategies and accept the need for change and sustainable innovation. In the coming millennium European higher education will undergo a complex and stressful set of changes. On the one hand, state budget constraints are not going to disappear in the short term. Hence universities will need to find new sources of funding, which will require in-depth analysis of performance in teaching and research. It seems that most countries are looking for ''organizational'' solutions, new structures and processes for efficiency and effectiveness. On the other hand, problems will arise as a consequence of this restructuring.

Shifting authority structures between administration and faculty, the changing role of university lecturers as service providers, and the differences in the attractiveness of various

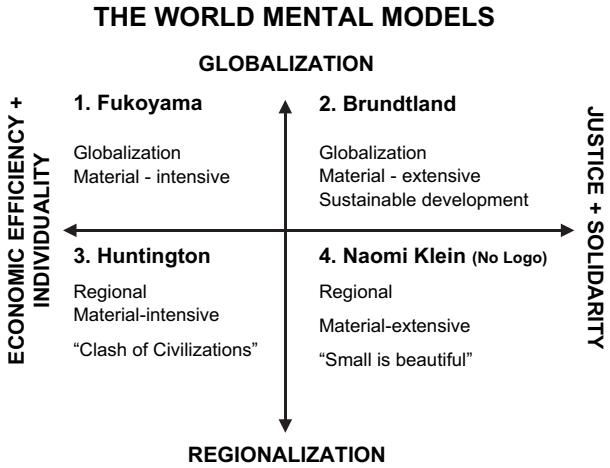

Fig. 8. The World Mental Models. Source: [29].

disciplines and fields will lead to major internal conflicts. It remains to be seen how the universities of the 21st century can reconcile their traditional role as places for a liberal education with market requirements. Because of demographic pressures the competition in the education market will become stronger and the expectations and needs of learners will grow and become more focused and quality and skills oriented. Since institutional leaders and academics may no longer be able to sustain themselves or even cover the basic necessities, they will need to turn to international funding, exchanges, and partnerships [30]. International funding and transdisciplinary and interdisciplinary research partnerships may be a light in the tunnel in setting the right priorities for research topics which should be focused on sustainable, innovative, adaptive and balance-seeking solutions to problems at regional level but within the global context. The better the student generation and their teachers understand the present world, the better they are prepared for future challenges, setting these priorities and seeking solutions to current problems in their regions.

It is a weak point in modern research funding that projects which are truly innovative are often not funded because they are unpredictable, while fashionable commonplace topics are favored. Thus on principle it is the most sensational and not necessarily the most innovative and sustaining research topics which are given highest priority. The present common practice, in expanding the politically controlled section of science funding, is counterproductive in view of the goals of SD [31].

6. Conclusions

1. The concept of sustainability can become effectively operational only if consensus and balance is found in its conflicting constraints by means of optimized, win-win solutions, apt for the situation and local/regional cultural dimensions and conditions.
2. In seeking self-similar solutions as best practices, it is important to make sure that the global context is included and that global and local solutions are in harmony.
3. Linking the global and local contexts of sustainability and sustainable solutions may become easier if a cultural dimension is incorporated into this process, so that global sustainability can be implemented by means of bottom-up initiatives.
4. The global context of sustainability should be the driving force for seeking local and regional solutions.
5. Communication processes (dialog) between humans, technology and nature, as well as regions and cultures will enable feedback from the implementation phase and will prove the correctness of a selected solution, making optimization still possible.
6. New types of technology (symbiotic) will be needed to enable the transition to take place from unsustainable practices to sustainable ones.
7. The education sector and academic research have an important role to play, but only if interdisciplinary and multidisciplinary thinking and learning are brought to bear, and problem-solving teaching methodologies are applied.
8. The research priorities set and financed should support truly innovative solutions. To make this happen serious changes are required in the academic and research community and in the universities themselves.

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