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EVOLUTION OF REGIONAL SOCIO-ECONOMIC SYSTEMS TOWARD "ISLANDS OF SUSTAINABILITY"*

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ABSTRACT

This article investigates the transition process from the unsustainable to the sustainable socio-economic system. It is assumed that this transition process can be characterized as an evolutionary process. In order to build a bridge from biological evolution to sustainable development the fields of complexity and entropic development are investigated. Furthermore the article emphasizes that sustainable development will most probably be introduced at the local level first. These point-like sustainable systems are defined as Islands of Sustainability (IOS). IOS are characterized as "innovative disturbances" able to jeopardize the structural stability of the unsustainable system, and hence, able to introduce wider sustainable development. It is argued that the development of IOS and furthermore the transition toward wider sustainable development is connected to the state of the ongoing paradigm change from the mechanistic to the holistic (synergetic, network) paradigm.

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INTRODUCTION

The time we are facing today is characterized by transformation and change of the structure of the socio-economic system. The human system is at a cross-roads in its further development. Since the mid-1970s a paradigm shift has been predicted [1-3] and the process of transition, the world between the old and the new paradigm, is described by anomalies and creative chaos. The myths of equilibrium which have been dominating the Western world are replaced by rather radical forms, the myths of resilience [4].

All mechanisms in the socio-economic system which occurred with great regularity for many years are now jeopardized in their stability, as new patterns and structures compete with old ones. In the economic system, for instance, this transition is described as transition from Fordism to Post-Fordism [5]. One of the theoretical scenarios for the future Post-Fordism is the "flexible specialization approach" [6], wherein is assumed that flexible specialization will lead to regional clusters of industrial production systems and therefore to strongly integrated regional economies. Furthermore it is assumed that Post-Fordism will leave behind mass production, as introduced by Henry Ford in America during the 1920s and 1930s [5].

The industrial production system considered from the viewpoint of matter and energy flows is undergoing a remarkable change, too. The typical throughput systems from resources to wastes are evolving toward "cradle to cradle" systems [7] with closed-loop structures as described by the Industrial Ecology approach.

Even though there are no direct links between the *Industrial Ecology* and the "flexible specialization approach" some of their features do point in the same direction. The proximity of production units on the one hand and the intensive exchange activities between them on the other can lead to new industrial clusters and networks which are stronger from an economic viewpoint, more effective regarding their resources consumption, and furthermore characterized by higher levels of resilience of the system.

Another transition process worth mentioning is the *back to place* movement called "Bioregionalism." Although *Bioregionalism* is focusing more on the problem of boundaries of the region [8, 9] and on ecological aspects, one can detect some similarities between *Bioregionalism* and the *flexible specialization approach.* If *flexible specialization* comes to replace Fordism it may augur a return to self-sustaining regional economies [5]. It is questionable whether this will lead to a general return to *place* [10]; however, the focus on spatial proximity and agglomeration of small-scale production systems, decentralized structures, new forms of regional networks based on trust and cooperation and a regional reorientation in general can be found in the literature of both Post-Fordism and Bioregionalism.

This small sample of developments dealing with the *new age* from the viewpoints of different disciplines, can only be seen as first parts of the mosaic of a new paradigm which might lead to sustainable development. It is argued that the transition from the unsustainable to the sustainable system is not just (technological) progress but evolution of the human system. In order to provide this new viewpoint of sustainable development, interpreted as an evolutionary step, it is the task here to give a brief overview of the meaning of evolution in biological systems first, and furthermore to investigate complex systems in order to build a bridge from evolution and complexity to sustainable development of regional systems.

Evolution of the Human System

When we speak of evolution, one central consideration is the history of the system. The history and the evolution of a system are closely related, but not identical. "In the history of such systems the elements of progression in time, of development, is lacking" [11, p. 20]. Undoubtedly, evolution is a directed process. Nevertheless, we meet with difficulties when we try to characterize its direction. If it is stated that evolution proceeds from simpler to more complex forms, from less specialized to more specialized forms, or from less probable to more probable states, the direction of evolution is not sufficiently defined [12]. Other characterizations have been given such as: evolution is an irreversible process, and it is directed to increasing organization. Lotka's Maximum Power Principle, sometimes called the fourth law of thermodynamics, defines evolution as follows:

> In every instance considered, natural selection will so operate as to increase the total mass of the organic system, to increase the rate of circulation of matter through the system, and to increase the total energy flux through the system, so long as there is presented an unutilized residue of matter and available energy [13, p. 148].

Odum comments on the maximum power principle as the most general design principle of self-organizing systems [14]. Social and ecological communities evolve toward a higher level of energy dissipation. On the bases of the theory of dissipative structures higher levels of energy dissipation correlate with the generation of complexity [15].

With evolution in human systems entirely new pathways are followed. The rapid development of the human system, the anthroposphere containing all artificial aids, has never been evolution in the sense of the maximum power principle. To maximize the energy throughput of the system is the guiding principle of evolution, but it is not unimportant where this energy comes from (see Figure 1). In the case of fossil energy stocks this energy comes from within the earth system and is therefore not an energy throughput (input from the past). The development of the unsustainable economic system can by definition not be denoted as evolution and, hence, the exosomatic evolution was not an evolution but merely a progress.

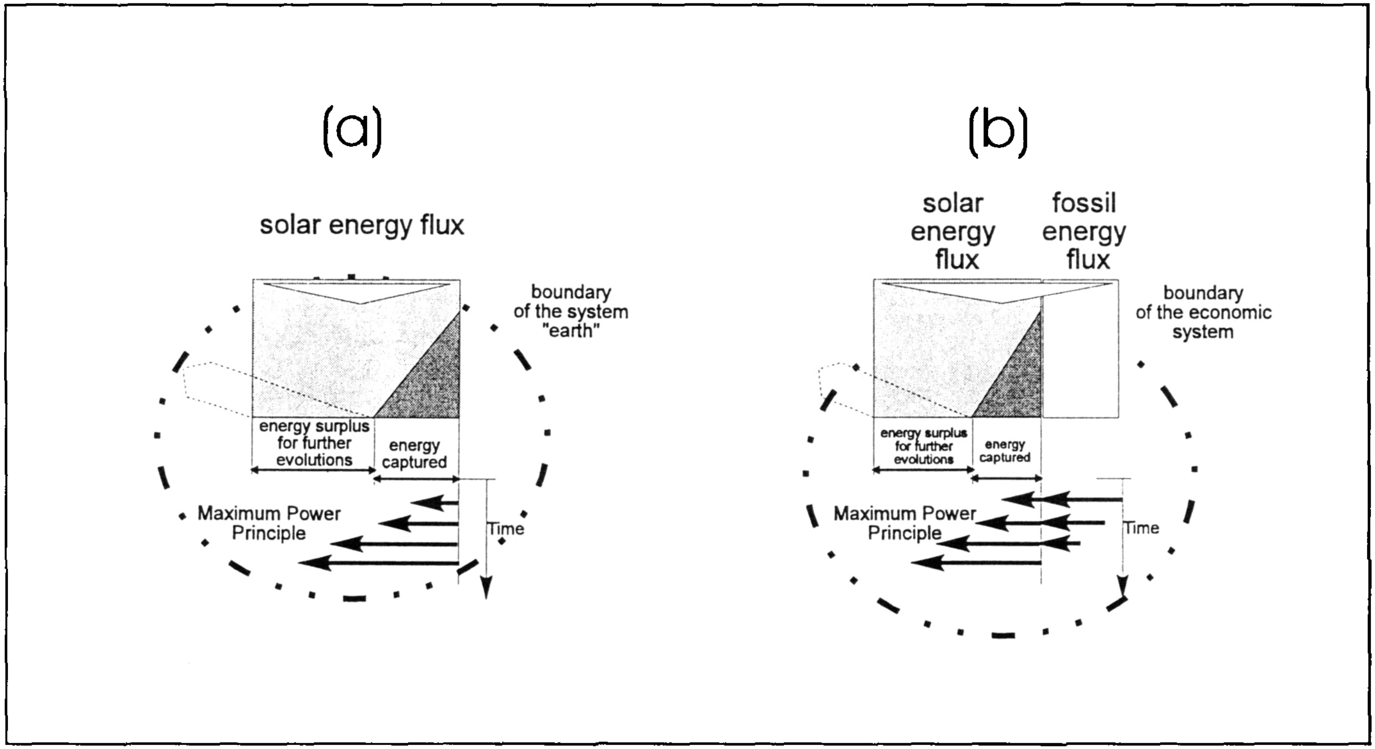

Figure 1. (a) Illustration of the Maximum Power Principle, formulated by Alfred Lotka (1922). To maximize the energy throughput is the principle of evolution. (b) Human progress made possible by the excessive use of fossil energy stocks was not in accordance with the maximum power principle.

In biology the maximum level of complexity a community can reach depends in part on its ability to use solar energy. Up to now, mankind has mostly created systems of what might be termed "simulated" complexity. Thinking of the complexity the anthropogenic systems, attainable on the bases of the present solar energy use, we would meet with difficulties maintaining just a few *pieces* of the system. We therefore suppose that the human system is beyond the state which would demonstrate the real complexity of anthropogenic systems. The creation of all structures and forms of organizations branches of energy from fossil stocks (see Figure 1b). The maintenance of the complexity of the present socio-economic system is based in part on these *fossil credits* for which return is hardly thought about.

Since the total effect of exploiting fossil energy stocks of the earth was not considered or known, the utilization of these *available* energy resources may be portrayed as an outcome of the *life struggle*. This view reflects Lotka's claim that "in the struggle for existence the advantage must go to those organisms whose energy-capturing devices are most efficient in directing available energy into channels favorable for the preservation of the species" [12, p. 185]. When the way of energy-capturing of the humans is understood as "cheating" on the biological evolution, it can be argued that generally changing course is the consequence. In this anthropogenic *game*, we are not only betting our own living conditions but also betting the living conditions of future generations. Lotka also had a slight presentiment of some less pleasing aspects of humans exosomatic *evolution*, considering a world at war. However, the *war* against the environment could not be recognized at that time.

THE COMPLEXITY OF THE HUMAN SYSTEM

In talking about complex systems or, better, complex system behaviour, we have to get an idea what complexity means. In Nicolis we can find the following description of complexity: "Complexity is an idea that is part of our everyday experience. We encounter it in extremely diverse contexts throughout our lives, but most commonly we get the feeling that complexity is somehow related to the various manifestations of life" [16, p. 6].

Rosen gives an introduction into the nature of complexity. He points out that "Organisms, and many other kinds of material systems, are not mechanical in this sense. Rather, they belong to a different (and much larger) class of systems, which we shall call complex" [17, p. 166]. To describe complex systems, such as organisms, the mathematics of the Newtonian paradigm is inadequate. Only very few types of systems can be described that way. Complex systems need a new mathematical image. For example the causal categories cannot be segregated into disjoint classes because some elements play several roles. Furthermore these causalities can be transformed with time because complex systems develop. It might be possible to describe parts of a complex system at a local level with simple (mechanical) mathematic models, but on larger levels these simple models are no longer valid. The reductionistic paradigm (Newtonian paradigm) fails when dealing with complex systems. Complexity is not just complication which could be described by a more complicated mechanical model. A new language (in a new holistic paradigm) has to be found (see [17, pp. 193-202] to accommodate these systems).

Bennett gives a list of possible candidates for formal measure of complexity [18]. *Life-like properties* can definitely occur only in complex systems. Hence, these properties may point out characteristics of a complex system. On the other hand we can find complex systems without such properties and functions, so that this kind of properties cannot be a necessary condition for complexity. *Thermodynamic potentials* (free energy, entropy) can characterize the potential of a system for an irreversible development. However, there are systems with higher free energy levels but lower subjective complexity than others (for example a sterile nutrient solution, with high free energy level and low complexity, and a bacterial culture, with low free energy level but high complexity). Logical depth, thermodynamic depth, self-similar structures and chaotic dynamics and a few other candidates are described in detail in [18].

In Odum, we can find the following definition of complexity: "Complexity is a property of systems concerned with component parts and their connections. Complexity is measured as permutations, entropy, information content, and statistical parameters and by energy flows" [14, p. 302].

Even though complex systems are often understood as biological organisms this view has changed since the introduction of irreversible phenomena in the thermodynamic theory, mainly by Prigogine [19]. The field of complex system behavior is not limited to life structures and therefore to biology. Self-organization phenomena were discovered in physico-chemical systems, which were thought to be *simple*. In open systems far from equilibrium, space-time structures may arise, and this spontaneous increase of order is called self-organization.

Following the introduction given by Nicolis and Prigogine, the most important vocabulary for our investigations is *dissipative systems, bifurcation and symmetry breaking* and *structural stability* [16, pp. 43-78]. *Dissipative systems* are characterized by the irreversible processes. The most important and also well-known for a long time is friction. Dissipation is always associated with energy, and in this very sense with energy loss. To describe dissipative systems on a macroscopic level collective variables can be used (e.g., temperature, pressure, and others). It is a very important difference between conservative and dissipative systems that time reversal of special events is not possible for dissipative systems (irreversible processes). *Bifurcation and symmetry breaking* is the next point to discuss. When the state of a system is moving away from equilibrium, a critical value of a parameter might be reached. At this point, the system has to decide between two possible events. In the case of the Bérnard cells, mentioned as an example in [19], the system has the choice between left- or right-handed cells. The problem of bifurcation can be illustrated using the bifurcation diagram (Figure 2).

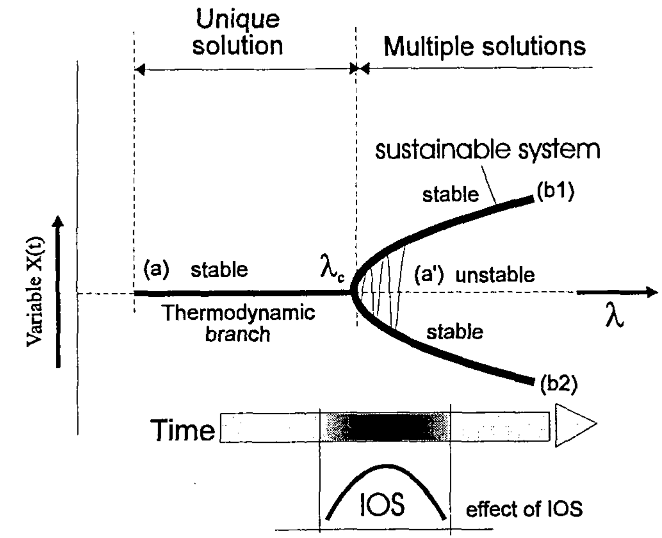

Figure 2. Bifurcation diagram. State variable *X(t)* as a function of a control parameter λ. When the control parameter *is increasing the systems behavior is stable. The unique solution is called the thermodynamic branch. At a critical level of* λ = λc the system loses its stability. The system has the choice between two new stable branches (b1) and (b2). This phenomenon is called bifurcation (source of the bifurcation diagram: Nicolis, 1989, p. 72).

For values of a chosen control parameter λ smaller than λc, the critical value, the system is stable. The state of the system is called a thermodynamic branch. In this field the system can eliminate perturbations, it is asymptotically stable. Moving farther away from the reference state, the control parameters reaches the critical value λc. At this point the system loses its stability. The thermodynamic branch (a) changes to (a′) which is no longer stable. At this stage the system has to perform a critical choice. The new branches (b1) and (b2), which are introduced, are both stable. Sticking to one of the new branches (b1) or (b2) the system has broken the symmetry (*symmetry breaking*), that means that the system has made a decision for one alternative.

The term *structural stability* is very important when dealing with self-organizing systems. The concept of structural stability can also be described as follows: "The concept of structural stability seems to express in the most compact way the idea of innovation, the appearance of new mechanisms and a new species, which were initially absent in the system" [19, p. 109]. The structural stability of the system is jeopardized, when unknown innovations act as local perturbations. Whether these innovators can infiltrate the system and change its behavior is a question of structural stability. It will be argued later on that Islands of Sustainability can act as local perturbations.

THE "FRACTAL ENTROPY COVER"

The earth we are facing today is a highly complex organism and is thought to be a living structure itself. Self-regulation structures have been found and have been described in great detail [20, 21].

The overall level of entropy of the earth is decreasing while the entropy of the sun is increasing. Characterizing the development of the entropy on earth with a graph, a straight line can be drawn as the initial state. After some time of evolution this line is getting more complex because of the process of differentiation. ". . . life could not make a continuous ectoplasmic mantle over the entire earth and broke down in pieces that became separate for further differentiation" [22]. The formation of living structures is represented by local minima while the affected surrounding increases its entropy and is therefore represented by local maxima of entropy. As this observation can be repeated on different levels of biological communities, the structure of this line or cover is called fractal. The cover representing the entropic development on earth can be called the *fractal entropy cover* (Figure 3).

A community on earth has to integrate itself into global developments. Therefore human developments have to be embedded into this structure of entropic evolutions. It is assumed that a behavior which is in conformity with the entropic development described above will guarantee sustainability. It is therefore a sustainable behavior to increase the level of complexity of the world. That means that the meanvalue of the fractal entropic cover must decrease.

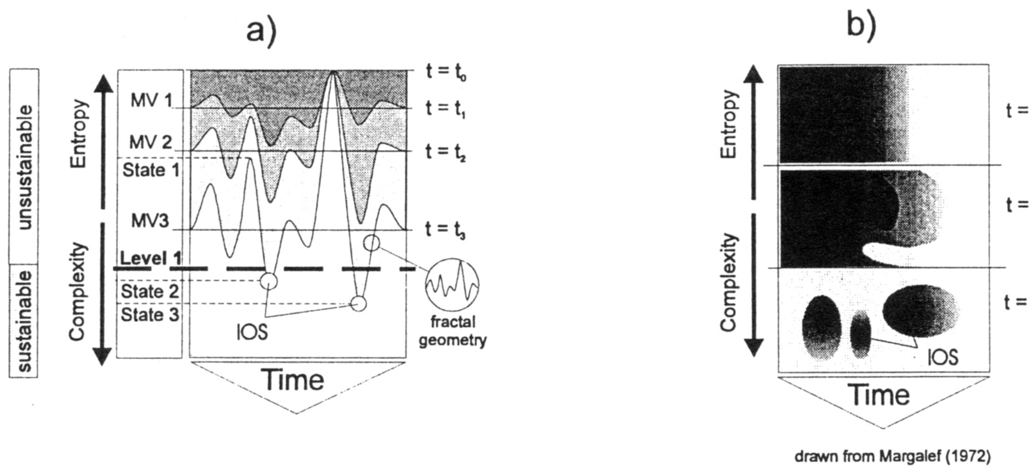

Figure 3. (a) Entropic development of complex systems with time. The fractal entropy-cover is defined. The overall level of complexity is increasing. Relative minima and maxima are trifting steadily farther apart. (b) Development of complex systems characterizing the process of differentiation.

Creating anthropogenic systems of low entropy levels on a local scale while transforming entropy into the environment is definitely not sustainable but is done by humans today. Even though this entropy shift is a primary characteristics of life structures we have to recognize an important difference. While life structures build up low entropy structures on the base of solar energy, human systems are mostly build on fossil credits as mentioned before. Entropy sinks of the developed countries are the biosphere and, arguably, developing countries. At the global level a huge amount of entropy is produced because of this use of *cheating* energy sources (fossil energy resources). In that way only entropy is produced without gaining new biological structures (biomass) which would create their order from solar energy, and as a consequence transmit entropy to the universe.

Another way of producing entropy is the high rate of material dissipation into the biosphere. Geological resource stocks are getting exhausted and after a short life-cycle all produced low-entropic structures (materials and commodities) are dissipating into the biosphere.

According to the perspectives we have discussed, sustainability can only be achieved when following the pathway natural evolution shows. Looking at biological systems of the ecosphere the production rates of entropy are high because the levels of energy dissipation are very high. The energy dissipation is necessary to maintain the complex order of the system over time. The energy used for dissipation is gained out of solar energy. The more complex the ecosystem, which means high biodiversity and small redundance of information, the higher the rates of energy dissipation (see [15] for a detailed discussion).

Hence, high entropy rates of human systems do not necessarily mean that they are not sustainable. On the contrary, it can be assumed that sustainability of the human system, which means a system of higher complexity, can only be achieved at higher levels of (solar) energy dissipation than we are facing today. Even if the entropy rates are higher than those of ecosystems at the same location the human system can be sustainable. The condition which has to be fulfilled is that the effectiveness of gaining energy from the sun is higher than that of the ecosystem. This assumption is in contradiction with the assumptions of: "If the entropy rates of human system exceed the rate for the reference system, then these human systems cannot be sustainable" [23]. They assume that the highest entropy production rate which is sustainable is that of a climax ecosystem (spatially averaged) on a given area. At this point the role of high technology as a means to reach sustainable development has to be emphasized.

SUSTAINABLE DEVELOPMENT AS AN EVOLUTIONARY PROCESS

Islands of Sustainability as Cells of Development

What are Islands of Sustainability (IOS)? IOS are regions, cities, or any other sort of local communities which are on their way toward sustainable development.

It has been argued that IOS are characterized by higher levels of complexity of the local networks [24]. The interplay of local and regional actors of various kinds within the freedom of certain constraints from the environment becomes the key-factor for sustainable development. In Nicolis and Prigogine, we find that "the evolution of such a system [human system] is an interplay between the behaviour of its actors and impinging constraints from the environment" [16, p. 238]. The constraints of human systems may be of many different kinds. However, the tension between an actual behavior and the desired behavior might be the constraints of social systems.

It is argued that the transition from the unsustainable toward the sustainable system is an evolutionary process. Hence, IOS evolve. Drawn on biological evolution it can be said that this is a process toward higher rates of circulation of materials within the system, and toward an increase of the total solar energy flux through the system. It is furthermore a process of differentiation toward higher diversity and complexity of the regional system.

In Figure 3 (a) the development toward higher complexity is shown. An IOS can be regarded as a regional system characterized by a certain level of complexity. State 2 and 3 can be interpreted as IOS while state 1 would represent an island of unsustainability. Being the sustainable system beyond complexity of level 1 (Figure 3), the whole (global) system can only become sustainable with time, when the meanvalue (MV) reaches that level (Level 1) of complexity. This drawing also tries to explain why sustainability will most likely be reached locally first. Therefore it can be supposed that top-down planning and the inherent wish to change the whole system at once, somehow runs contrary to the law of evolution and can therefore never succeed.

In Figure 3 (b) it is shown how the process of differentiation accompanies the increase in complexity. For the three moments of time (t1, t2, t3) different levels of complexity are characterized by different levels of differentiation. Figure 3 (a) and (b) give two possible interpretations of one and the same evolutionary process.

How far does the evolution go on? Regarding the regional system there could be an upper limit to complexity similar to natural communities. The industrial process and production units of the regional system, e.g., form a network, they are interconnected. When the diversity of *economic species* becomes too high and their relations become too complex, the system loses its meaning (drawing on [22]). On the contrary, the present unsustainable regional systems are characterized by too-low levels of complexity and differentiation. The optimum level of complexity is therefore most likely the desired state of sustainable development of regional systems, in effect, the IOS.

What are the means to reach higher levels of complexity? There are ways to increase the networking activities within the open as well as the spatially limited socio-economic system. On the base of the systems analysis of regions given in [24] the elements of the regional system are called process units. A process unit is an entity which introduces communication activities such as exchange of information, materials, and energy. Examples of process units can be given such as enterprises in industry (production) and business (craft) power generations plants, and waste water treatment plants. All of them are characterized by cross-boundary flows of information, materials and energy. We will define other regional actors, such as households, schools, chambers or commerce, chambers of agriculture, political actors, and all other institutions also as process units as they are integrated into an information network.

The network of these process units has to become more complex. Therefore new forms of networks must be created as well as existing networks intensified. Acting this way the connectedness of the regional network increases [25]. However, a higher level of networking activities within the regional system (internal communication) leads to a necessary decrease of cross-boundary communication, so-called external communication. In order to make this possible, new nodes of the network must be created and the diversity of regional *species* has to increase. It must carefully be pointed out that it is necessary to find a balance between diversity and redundance especially regarding economic entities as well as between internal and external communication regarding the highest achievable resilience potential of the economic system. The optimum lies somewhere between autarchy (closed systems) and total dependence (unlimited open systems). The focus in IOS is on small and medium enterprises and their regional networks; however, for sustainability this is not enough. Regarding the global issues surrounding the concept, such as global equity and poverty, global embeddedness is absolutely necessary.

In the literature a remarkable tendency toward networking activities can be found. In economics the trend from markets and hierarchies to network forms of organization is described [26]. Also in the Post-Fordism debate the flexible specialization approach focuses on reliance on skills, flexibility and networking between task specialist units [5]. Also new forms of networking activities based on the exchange of materials (in this case mainly resources and wastes) and energy can be found. The theoretical framework is called Industrial Ecology and first sights of implementation of some parts of the concept can be found in Industrial Ecology Parks [27, 28].

Beside these networking activities described above, for an evolution toward sustainable development it is also necessary to investigate the process of differentiation. The regional system has to develop its boundaries. The boundaries of regions are discussed in the literature in great detail (see e.g., [9, 29, 34]).

The mostly historically set geographical boundaries of regions have to develop toward functional boundaries. In order to develop toward an IOS the region has to become an entity and therefore to come up with new structures and forms of organization. The IOS becomes functionally isolated. That means that the character of an IOS differs from the surrounding unsustainable regions. The new character is a consequence of internal interaction of the regional process units.

Here we draw on biological systems such as enzymes. "By increasing the reactivity of living systems, enzymes functionally isolate the system from its environment" and furthermore "If enzymes functionally isolate living systems by the rate of their reactions, the necessity for a cellular construction at the origins of life is obviated" [30, p. 68].

However, functional isolation does not mean that the IOS is a closed system regarding communication with the environment. There are certainly energy, material, and information flows across the boundaries of the IOS. Furthermore, the evolution of regions toward IOS brings up a new type of boundaries which are time-related boundaries. They become important because of the intermediate character of IOS as will be discussed later on.

The formation of functionally isolated systems is a nucleation process and can be compared with the process of condensation, used as a physico-chemical analogy. The use of an analogy makes it easier to explain the transition process. In physico-chemical systems a phase transition, e.g., from gaseous to liquid state (vapour to water) or from the liquid to the solid (water to ice) state, never happens instantaneously throughout the system. It always starts locally introduced by condensation or crystallization cores. We can take this model to explain the creation of IOS. In a first step the crystallization core, so to say the IOS, has to change its thermodynamic phase from the liquid to the solid state, and in analogy, the unsustainable region has to become an IOS. This is thought to be a nucleation process as the IOS forms new functional boundaries. In order to reach higher levels of complexity this nucleation process is necessary. In Figure 3b the process of differentiation is described.

This increase in complexity also leads to higher stability of the system, as we can find in: "The higher level of stability of the world is caused by a higher differentiation of its subsystems, that is, by an increase of its complexity and its level of organisation" [31].[1] As sustainable development has the inherent condition of sustaining the socio-economic system for a long period of time, stability of the system is a critical issue.

Transition toward Wider Sustainability

Why are IOS necessary for wider sustainable development? Drawing again on biology, sites of higher organization tend to be pointlike, closed and protected. Nucleation is always necessary for further evolution and is combined with the possibility of copying organization. High concentration of complexity can be found in disperse places and always of limited extension [22]. Furthermore, in

[1] Original text in German: "Die höhere Stabilität der Welt wird durch eine höhere Differenzierung ihrer Untersysteme erkauft, d.h. durch ein Ansteigen ihrer Komplexität und ihres Organisationsgrades."

[32] we can find that the speed of evolution of complex forms is greatly affected by the existence of stable intermediate forms.

Islands of Sustainability can be interpreted as temporarily stable intermediate forms of local sustainability. IOS are supposed to act as local innovations, and as a *sustainability alien* within the unsustainable system, to introduce new structures and forms of organizations which jeopardize the structural stability of the old system. The critical question arises, whether IOS, embedded in a non-sustainable economic environment, are able to reach a temporarily *quasi steady state*, that is, whether they can act as cells of development for a brief period of time or whether they are erased immediately. The period of their existence does not need to be very long, since a long coexistence of IOS and an unsustainable system is not desirable. IOS would lose their function as cells of development and *innovative disturbances* after a while because the system would get used to them.

It is then a question of the boundary conditions whether these *innovative disturbances* are able to introduce a transition of the wider system towards sustainability (Figure 4). However, without having the right preconditions for the transition process, IOS will not be highly effective. In this case maintaining IOS would only be a waste of energy and money as they would degenerate from *innovative disturbances* to a *Disney Park.*

On the one hand the creation of IOS destroys or at least disturbs locally the structure of the old system and furthermore questions the structural stability of the wider system. Primarily it is a destructive process. On the other hand, the process of change releases new opportunities and is therefore a creative and innovative process. To characterize the function of IOS we suggest the term *innovative disturbance*, which is similar to Schumpeter's [33] term "creative destruction" but less strong.

In Figure 2 the bifurcation diagram is given. The present unsustainable system, the unsustainable branch, can be interpreted as the unique solution. Under present socio-economic conditions only the unsustainable system is stable. IOS as innovators can jeopardize the structural stability of the system. When the control parameter, in our case possibly the state of the ongoing paradigm change, reaches the critical value, the unsustainability branch is not a stable solution any more. One of the new arising solutions might be the sustainable system as desired. However, we have to be aware that it is impossible to predict the outcome of such a transition process. There is no guarantee that the sustainable system is able to represent a stable solution.

Boundary Condition for the Transition Process

Regarding the physico-chemical analogy, the process of crystallization, the boundary conditions are given by the state variables such as temperature and pressure. Only within a certain range of temperature and pressure can crystallization cores be utilized and as a consequence introduce the phase transition

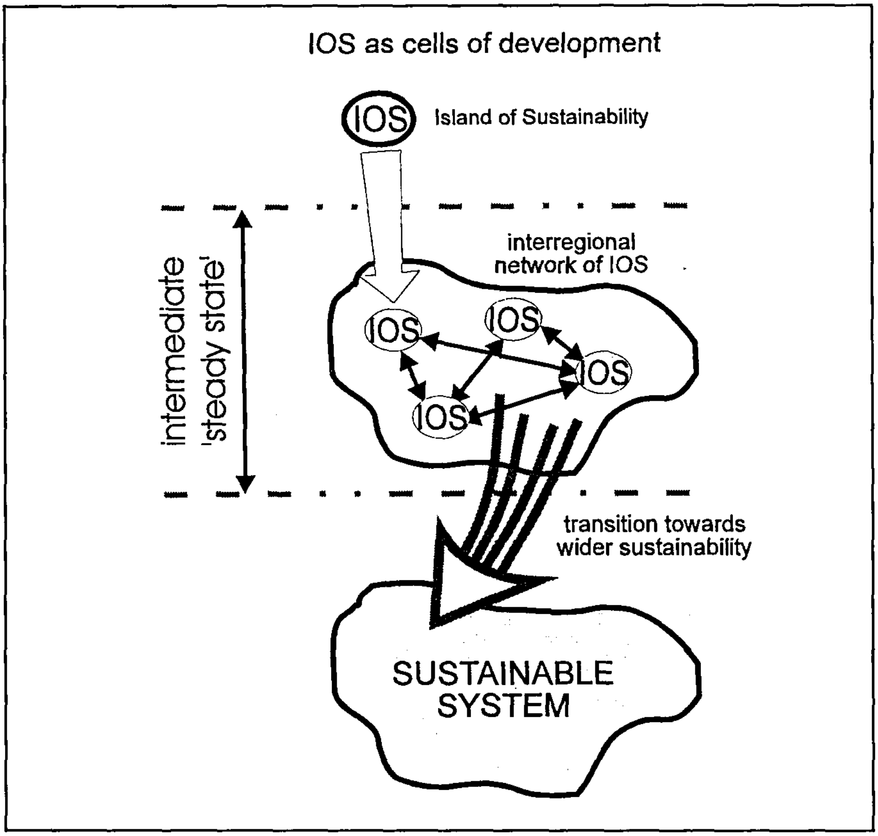

Figure 4. Transition toward wider sustainability. The evolution process of the socio-economic system is introduced by "innovative disturbances," the IOS, acting as cells of development.

process. For the transition of the human system from unsustainable to sustainable development the boundary condition can be interpreted as the number of problems for which there is no solution, or in other words, the state of the paradigm change form the mechanistic to the holistic (synergetic, network) paradigm.

The fact that a paradigm change is a rather slow process can be interpreted taking up on Sheldrake's idea of morphic fields [34]. Social and cultural patterns are *written* in so-called morphic fields which have a stabilizing and conservative effect. The present unsustainable socio-economic system is now greatly facilitated by morphic resonance and hence, this is a major obstacle for new structures and organizations to overcome. Here again we can find arguments for IOS as it appears rather obvious to be easier to develop against morphic resonance of the old system in a pointlike way than fighting the whole block at once. "But once new patterns of activity have arisen, the spread and adoption of these innovations may well be facilitated by morphic resonance" and often repeated patterns of social change may be stabilized by morphic resonance [34, p. 246].

Some of the engraved patterns working against sustainable development are rather obvious. Unsustainable socio-economic systems tend to be maintained by subsidies. If subsidies for maintaining Fordist industry were shifted to the development of IOS, it would lead to tremendous disruptions. In order to avoid a total break-down of the socio-economic system, this necessary shift of subsidies must be handled very carefully. The break-down of the socio-economic system would not make any sense. What is needed are innovative disturbances. Whether the wider system reacts positively to these innovative disturbances and is going to change depends on the character of the *surprise*. Surprises must not destroy the system before it can make any use of the event [4].

To foresee the time of the ongoing change we have to be aware of signs, in other words we have to be on the alert for slight ongoing crises. These crises of the systems are described, e.g., in [2]. Crises infiltrate not just some parts of the system but the whole. Examples can be given such as crises in our economy, crises in science and in society, in health and of course in the biosphere. It must be emphasized that the society has already partly lost its capacity for solving these problems.

FUTURE OF IOS

In future work on IOS it is necessary to flesh out case studies more intensively. In these *experiments* the focus should be given to social and economic aspects. Early IOS in Europe can be test-tubes and achieve at least a useful demonstration effect. In Austria the first experiment on IOS can be given with the ECOFIT-project (Ecological Region Feldbach with Integrated Technology) [35]. This project is only seen as a first step toward an IOS and gives mostly an analysis of the potential of the Feldbach region for becoming an IOS in future.

The spatial proximity of regions and other types of local communities raises the problem that only some aspects of the whole sustainability debate can be addressed. Where are poverty and global equity in the IOS concept? What about the process of globalization? Where is world trade? These questions cannot be answered yet. In general it can be mentioned that it is a difficult task to find the most appropriate physical scale, such as township, state, regional, national, or international entities, for the implementation of sustainable development [36].

It must also be questioned whether the concept of IOS creates a possible pathway for the rich (developed countries), the poor (developing countries), or even for both. Is there a chance for huge cities such as Rio de Janeiro to become an IOS? As the concept has been developed during a project on regional sustainable development in Austria (mentioned above) it is thought to be a possible initial framework for Europe. However, there is no reason for not shifting this concept to other continents when it is, necessarily, embedded into the cultural environment. Regarding Rio de Janeiro (for example) it has to be asked whether the priorities for action and development might not be totally different and hence, the focus be on questions of survival no matter whether or not in a sustainable manner.

The fact that there are also some global activities quite similar to the concept of IOS can be shown by giving the example of the "Models of Sustainable Development (MSD) Project" [37]. This project tries to deliver sustainable development to a sample of seven to ten regions around the world.

In the future it seems to be a possible pathway for development toward sustainability to concentrate actions on a sample of regions in Europe or even around the world and fostering a network of IOS. These case studies would provide new insights on what can be done locally in different countries under different conditions and furthermore teach us where and how sustainability efforts are most likely to succeed.

CONCLUSIONS

We have argued that the transition toward sustainable development of the socio-economic system is an evolutionary process. It is a step toward higher forms of organization, more intensive networking activities, and, regarding a regional system, a step toward a higher solar energy throughput and higher internal material cycles.

This evolutionary process will most likely be introduced at a local or regional level. The first cells of development, characterized by higher levels of complexity, are called Islands of Sustainability (IOS). They act as innovative disturbances and jeopardize the structural stability of the whole unsustainable system. Under optimum conditions IOS can introduce wider sustainable development.

Taking the "fractal entropy cover" as a framework for explanation, it was stated that the IOS concept fits into the natural law of evolution, starting the transition at the bottom. Top-down planning strategies, on the contrary, do not fit into this framework. It was argued that they can therefore never be successful in reaching sustainable development.

When drawing on the theory of complex system behavior an important statement for planning of human systems can be found:

> If a new activity is launched at a certain time, it will grow and stabilize. If the place is well chosen, it may even prevent the success of similar attempts made nearby at a later time. However, if the same activity is launched at a different time, it need not succeed; it may regress to zero and represent a total loss. This illustrates the danger of short-term, narrow planning based on the direct extrapolation of past experience [16, p. 242].

In other words, information gained out of past experiences will not be of much help for future decisions. This seems to be a very important perception for planning and decision making. The human system must be kept as flexible as possible to have a great potential to adapt to new environmental conditions; it must be prepared for surprises in order to survive in the long run.

The world is a world of *becoming* rather than of *being* [19]. We possibly prefer times of conservation but we have to face the change. "There are two principles in the very nature of things, recurring in some particular embodiments whatever field we explore—the spirit of change, and the spirit of conservation" [38, p. 250]. The time we are facing today is a time of change, maybe the time of the most rapid change ever experienced, and it seems to be a dangerous time for humankind.

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