

# **Sustainable Land Management – A New Approach for Implementation**

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**Key words:** sustainable development, land management, planning theory, chaos theory, people's participation.

## **SUMMARY**

So far, planning processes which are an important part of any sustainable land management are based on a system-oriented approach. System oriented approaches are, however, limited in capturing real phenomena. Unexpected influences and sudden changes are not included. Concerning land management, this means that unforeseen things which can be initiated by any decision during the planning phase cannot be regarded within the planning process. As sustainable development calls for a high degree of people's participation, many actors are included in the process and in its decision-making. The more people are included, the higher the degree of unpredictability.

Within this paper an attempt is made to overcome the limits of the existing planning theory based on systems oriented approaches. The main idea is to use elements of the chaos-theoretical approach to redefine and extend the elements of the well known system-oriented planning approach. It will be shown that by using a chaos-theoretical approach, improvements in sustainable (land) development can be achieved which mainly consist of a more sophisticated way of participation of all stakeholders.

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## **1. PREFACE AND PRECONDITIONS**

Sustainable rural and urban development is a contribution to welfare of mankind. It will ensure existing resources and provide better living conditions for future generations. Sustainable development can be achieved by many things. One major contribution to it is land management. Within land management planning – spatial as well as strategic – plays a key role.

Up to now this planning process is based on a system-oriented approach. The system oriented approaches are, however, limited in capturing real phenomena. Unexpected influences and sudden changes are not included. Concerning land management, this means that the participation of people as well as unforeseen things can not be regarded within the planning process.

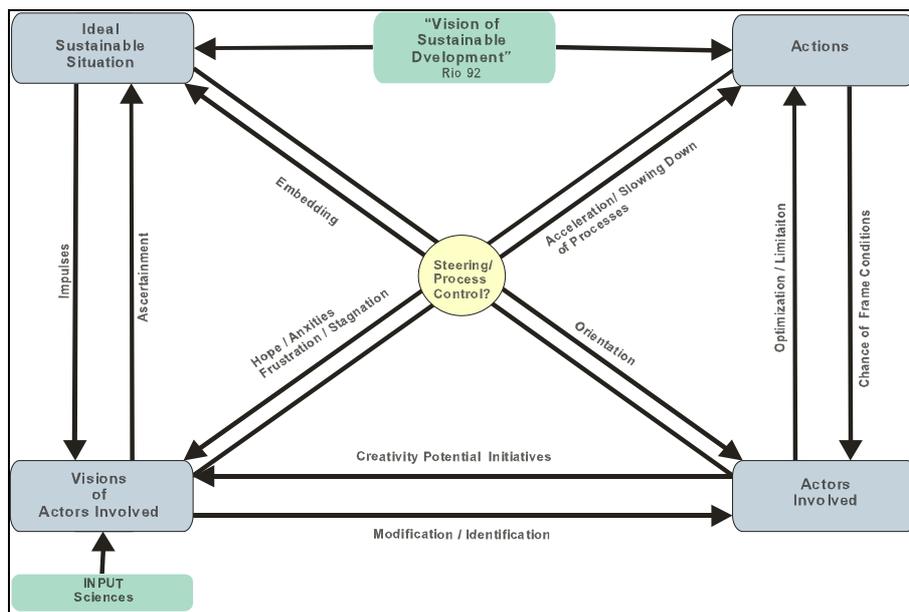
Within this paper a way will be shown to overcome these obstacles. The main idea is to use elements of the chaos-theoretical approach to redefine and extend the elements of the well known system-oriented planning approach.

## **2. THE SYSTEM OF LANDMANAGEMENT**

Considering the complexity of sustainable development, sustainable land management – being supposed to support a sustainable (land) development – has as well to be defined as process orientated as action orientated. It is not only a matter of what kind of development can be achieved but also of how this is done (e.g. participatory, transparent). When we look at planning, this means that we are not only interested in the final plan or its implementation but also in the actual planning process. What are the factors influencing this process?

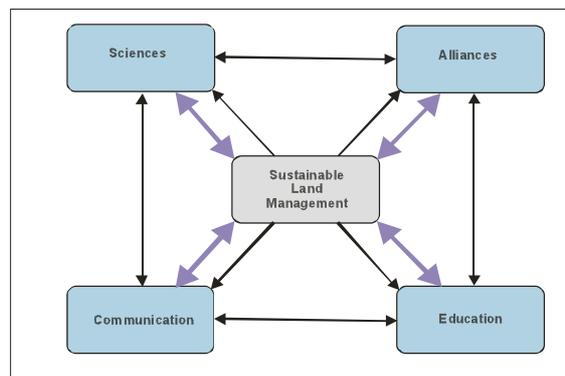
Sustainable development can be described as system framed by the ideal sustainable situation, the actors involved, their actions, and their visions (see fig. 1). Within this system interaction and mutual influences of all components of the system exist (WYTRZENS 2001).

**Figure 1:** System of Sustainable Development (own draft based on TROITZSCH 1999 and WYTRZENS 2001)



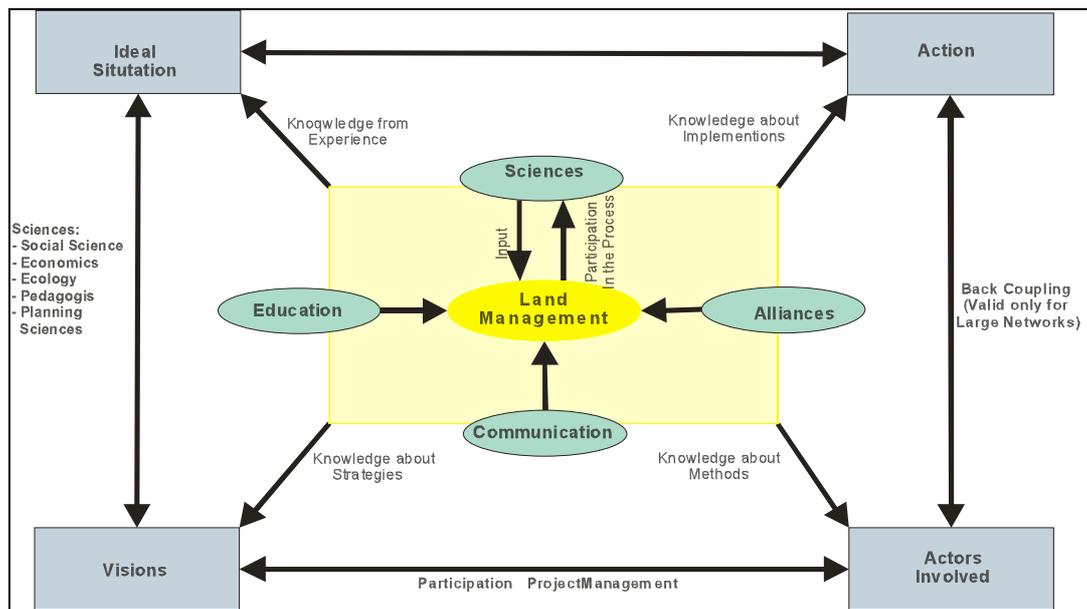
The subsystem sustainable land management has to be seen as a complex system consisting of the following components: sciences, alliances, communication and education which are embedded in a social and political context with permanent modifications. They are not independent from each other. There are also interactions and mutual influences (see fig. 2). Accordingly, they cannot be considered in isolation. There are actually no unambiguous relations because each factor can be described as a function of all other factors.

**Figure 2:** Sub-system Sustainable Land Management (own draft based on LASS/REUSSWIG 2000)



This concept (or definition) of sustainable land management becomes even more complex if the process of land management is put in the context of the above described system of overall sustainable development. The sub-system land management is now acting between actors, actions, ideals and visions (see fig. 3).

**Figure 3:** Interactions between the Sub-system Sustainable Land Management within the System of Sustainable Development (own draft).



This system can be compared to a non-linear equation composed of the above mentioned components, which has a multiplicity of correct solutions which are equivalent to possible actions. Consequently, mechanisms of chaos theory and especially fractal geometry can be applied and used to improve planning processes. Based on the mechanisms of chaos theory a process-oriented approach can be worked out to strengthen sustainable land management and to firmly establish sustainable proceedings in rural and urban communities.

### 3. KEY PRINCIPLES OF CHAOS THEORY

#### 3.1 What is Chaos Theory

Chaos-theory is a mathematical-physical theory for exploration of random non-linear processes but has recently also been applied to social phenomena. The corresponding research is called chaos-research and was developed during the seventies of the last century. The chaos research is examining systems during the transition from an ordered to a disordered (chaotic) stage and vice versa. It is describing phenomena which are based on certain physical laws but with unforeseen behaviour. This situation can be compared to planning processes. In involving a lot of stakeholders – which is necessary to receive excellent planning results that are supported by all parties – there is often a change from order to disorder and back. The participation of people also results in unforeseen processes and unexpected outcomes.

## 3.2 Main Principles of Chaos-Theory

For a better understanding of their application in planning theory, the main principles of chaos theory are briefly explained in the following section.

### 3.2.1 Bifurcations

Bifurcation means point of separation. In the field of system research a bifurcation is the critical point that provides different solutions to a problem. In this points a triviality can be enhanced by iteration, this means multiple repeating, thus that a diversion from the actual way will occur and the whole system will shift to a new direction (see BRIGGS/PEAT 1990, S. 212). Within the bifurcation lies the creativity of a system. The ability of a system to enhance little variations, is the key to creativity (see BRIGGS/PEAT 1990, S. 215). In terms of planning it could be said that in providing a creative environment a lot of alternatives can be put up and/or enhanced.

### 3.2.2 Strange attractors

BRIGGS and PEAT (1990, p. 49) are explaining that attractors represent an area in a phase space which is giving gravity to a system and seems to absorb it completely. The phase space is defining a space in which a motion takes place. Every degree of freedom or parameter of the system is represented as an axis of a multidimensional space. For every possible state of the system, or allowed combination of values of the system's parameters, a point is plotted in the multidimensional space. Often this succession of plotted points is analogue to the system's state evolving over time. In the end, the phase diagram represents all that the system can be, and its shape can easily elucidate qualities of the system that might not be obvious otherwise. A phase space may contain very many dimensions. The phase space consists of the number of variables the scientist needs to describe the motion of the system (see also BRIGGS/PEAT 1990, p. 49). Within such a system strange attractors take the task of an allocative function, thereby stabilizing or destabilizing the system. But this happens unconsciously and unpredictable. Strange attractors consequently can be used to influence decisions at bifurcations.

### 3.2.3 Iteration

Iteration means frequent repetitions that create very distinctive deviations. Those repetitions can also be seen as the passing through a loop. The system is leading back to itself. This provides an opportunity to open a window to chaos. A little shift in the initial data can lead to the fact that the system works not reflexive anymore but creates a new solution. This means that complex non-linear dynamic systems are very sensitive (see BRIGGS/PEAT 1990, p. 92). Little shifts in the initial data can be enhanced very fast if they were boost by repetition (refer also BRIGGS/PEAT 1990, p. 110). In this context, one effect called phase locking has to be mentioned. If different individual oscillating systems step out of the chaos with a harmonic resonance or connect to a common oscillating system, this is called phase locking.

Common oscillations produce marginal cycles which are more stable and adoptable than an accumulation of individual oscillations (see BRIGGS/PEAT 1990, pp. 283).

#### 3.2.4 Back coupling (feedback)

Effects of back coupling are fundamental in all exact sciences since the introduction of dynamic principles by Sir Isaac Newton and Gottfried W. Leibnitz (see PEITGEN ET AL. 1998). The back coupling effects – already known from the system theory but also used in chaos theory – are representing a fundamental tension between order and chaos. Coupling effects block or enhance the affected processes. The bigger the autonomy of an organism the more cycles of back coupling it will need (see HOISL 1994, p. 332). Within chaos theory back coupling has a special relevance. By means of back coupling cycles it is possible after decisions made at bifurcations to stabilize and establish the new development initiated by strange attractors.

#### 3.2.5 Intermittence

There is no common precise definition of intermittence (ARGYRS/FAUST/HAASE 1994, p. 551). The term intermittence is describing islands respectively windows of order in the sea of chaos or disturbances in an ocean of order. Order and disorder are rotating with each other. One cycle of iteration after the next one will be passed, while the system is moving in a chaotic (or orderly) manner through its phase space. In the areas of intermittence the old order (or the chaos) will be discovered again for a little moment. The same cycle of iteration which was producing a moment ago the chaos (or order) is leading to a certain order (or chaos) (BRIGGS/PEAT 1990, p. 87). Intermittences can be regarded as the memory of non-linear systems.

#### 3.2.6 Dissipation

In a physical sense dissipative systems are systems which are losing energy. A volume element in the phase space will in a certain point of time (approximation against infinity) contract to an attractor which dimension is less than the own phase space (ARGYRS/FAUST/HAASE 1994, p. 134). This can also be interpreted as striving for balance.

Dissipative systems can also be called dissipative structures. The term dissipative structure verbalizes apparently a paradox. Related to the loss of energy dissipation is implicating more falling apart and chaos than structure (see BRIGGS/PEAT 1990, p. 207). Dissipative structures are systems, which can keep their identity only in being open for influences from the outside. Conditions far away from balance are creating structures in the non linear area, which are creating order from the chaos. This can be regarded as effort to establish self-organisation.

### 3.2.7 Fractals

The idea using fractals for a new geometry (fractal geometry) is coming from Benoit Mandelbrot (see BRIGGS/PEAT 1990, p. 127). The term fractal is describing self similarity. A fractal is a geometric object which can be divided into parts, each of which is similar to the original object. Fractals are said to possess infinite detail, and are generally self-similar and independent of scale. In many cases, a fractal can be generated by a repeating pattern, typically a recursive or iterative process. The author of the idea of fractals became more and more aware that self similarity is not only an uninteresting characteristic but a mighty instrument to create shapes.

## **4. CONSEQUENCES FOR PLANNING AND SUSTAINABLE LAND DEVELOPMENT**

The described key ideas of chaos theory have already been transferred to the self-organisation of society (see KÜPPERS 1996). It is therefore quite obvious to apply them to planning processes.

### **4.1 Influencing Bifurcations**

Bifurcations are equivalent to decisions. TROITZSCH (1996, pp. 212) shows that the establishment of co-operations – and related to this collective behaviour – could not be predicted in detail because it is depending on continuously changing individual decisions. In that way only the probability of a certain outcome can be calculated, not the definite final situation.

The sensitivity of the system as well as the effect of little impulses could be used for land management. What is important is the influence respectively the control of the bifurcations (decisions). The necessary creative environment can be set up by establishing round tables or working groups or by the promotion of general communication. A further possibility is the promotion of a broad engagement of citizens. Seen from the main principles of chaos theory a higher importance has to be given to the beginning of land management processes. Within an **activation phase** using discussions with broad participation of key-persons and involved citizens is it possible to detect and/or create future bifurcations or control them as the case may be. Through this additional communication potential and creative environment will be established. The motivation of all stakeholders is necessary and should not be lost out of sight. Thereby a new potential of ideas could be gained from which the process of land management can profit. Motivation could be established through capacity building. Also (additional) functional inquiries are able to influence the process as well as a common evaluation of the present situation. Thus it is helpful to create guidelines, checklists and other instructions (see Klaus 2003).

### **4.2 Identification and Strengthening of Strange Attractors**

The application of the concept of strange attractors to the process of a sustainable land management raises two questions: How can the phase space of a sustainable development be

described? Which elements are acting as strange attractors? As phase space the actual framework defined by social values, informal processes and actions, involved stakeholders and legislation could be regarded. This is also including the three pillars of sustainable development (economy, ecology and social aspects) with their specific political, technical and legal actions.

Two groups of strange attractors can be defined: First, all institutions, groups and stakeholders involved in the process. Second, the elements of the process itself such as setting up visions and concepts. Extraordinary active actors can be seen as attractors which influence the framework of the process from inside – either in favour of sustainable land management or not. One single person participating in the process of land management and vindicating a point of view that differs slightly from a common point of view is able to establish a new position (through discussion and by convicting others) which might be supported by the majority. Planners, project managers or persons responsible for the process of sustainable land management therefore use conscious group-dynamic effects (compare to phase locking) and prefer to address opinion leaders for unconventional solutions. Principally all persons involved in the process can become strange attractors. One has, however, to be aware that strange attractors do not compulsory have to act in a positive manner. Strange attractors are directing a process by their decisions (within the bifurcations). These decisions can also have a negative impact on the whole process. Consequently, it can be concluded to work also on the commitment of the involved people (e.g. through further education) if they shall act as positive strange attractors within the process of sustainable land management. In this regard, the key-qualification “social competence” has to be taken into account. Positive strange attractors have to possess power of persuasion and be able to convey this. Therefore, only planners/moderators with a certain charisma should be selected. The same is true for the selection of key-persons within the process.

Visions and guidelines are also able to act as strange attractors. For this reason the development of visions has to meet certain requirements: they have to be set up in a close co-operation with the local people affected by the measures of land management. Superimposed visions can have a negative impact. In addition, training and education should be offered to all different groups of stakeholders corresponding to their specific needs and interests (see OERTER/HOEFLING 2001 or KEUPP 2000).

### **4.3 Critical Guidance of Iteration**

Taking into consideration that within iteration little variations in the starting situation can have massive consequences, the accuracy of initial data is of high importance. Little mistakes in the initial data can result in the loss of the reflexive characteristic of the system, thereby straying from the path of sustainable development. Therefore, lack of information has to be avoided and initial data have to be checked carefully. Also, iteration processes have to be guided critically. This is best possible by having a permanent process monitoring. Within land management iterations can be used in a positive way: if a chosen direction proves to be wrong and cannot be abandoned due to strong group dynamic processes, it makes sense to detect iterations and to boost them to leave the reflexivity of the system. HOISL (1994) is

stating that within planning processes iteration combined with back coupling could lead to a window of order in the ocean of chaos. This calls for a permanent monitoring which enables interactions at an early stage to enhance positive back coupling and to turn around negative ones.

If we take the mechanism of iteration as a basis of sustainable development it becomes evident that this process will never end. With changed frame conditions or new insights some of the already made objectives are falling back to chaos and order has to be re-established via new processes.

In combination with iterations the phase locking can be used to bundle different processes and produce synergy effects. It is imaginable for example that different working groups which have been following their own objectives for a long time suddenly recognize within a new communication space that they have common objectives. If they are regulating those objectives together, the overall output will be improved. This means that group dynamic processes can lead to phase locking.

#### **4.4 Encouragement of positive coupling back**

Back coupling is blocking or enhancing the affected processes. Especially at bifurcations, there exists a possible danger for the system to drift into the chaos. With processes of back coupling the system could be stabilized and anchored at fixed positions. Group dynamic processes play an important role related to coupling back effects. Therefore, it is necessary to implement certain panel for communication such as round tables: With back coupling based on communication the correlated process can be stabilized. Internal and external controlling units can help to force coupling back effects and to establish coupling back structures. Trough horizontal and vertical co-operations as for example between rural and urban areas (in the context of regional development) back coupling structures can be established and formalized.

#### **4.5 Utilization of Intermittences**

The active use of intermittences means to consciously use the alternation between phases of order and phases of disorder (uncertainty). The potential of innovation in the phase of chaos should be picked up courageously and be used for the further development of the system respectively the process. This means the creation and the conservation of a creative environment out of which new ideas and bifurcations can arise. Seen from this perspective the establishment of a communication forum like a round table and active participation are very important. It should be considered to implement a start phase and extent it as long as possible to catch all creative ideas. This can be done by installing a round table. The round table has the task to work as creative pool. In this context, measures of further education become more important too, because they also create a creative environment which is helping to overcome inherited structures. With the use of modern forms of participation, as for example the internet, it is possible to mobilize additional potential for innovations.

In this context, the role of single municipalities within a region deserves particular attention. Through regional development individual communities – rural as well as urban – can be taken out of isolation. The alliances of municipalities are opening the way to new creative potential and therefore new ideas for partnership.

A combination of these elements (further education and regional development) can strengthen these aspects. This operates back directly to the bifurcations. It is therefore necessary to implement such concepts within sustainable land management on a regional level.

#### **4.6 Dissipation – a way to new solutions and self-responsibility**

Dissipation in the sense of self-organisation and self-reliance permits to keep the process of land management open for new impulses and avoids the drift into the chaos. On the contrary this openness is strengthening identity. To boost identity and provide the openness to new influences motivation of all persons and institutions involved in the process is necessary. This guarantees to be open minded to new and unconventional solutions. Delegating the realization of single measures to associations of citizens, informal institutions and the private sector is promoting self-reliance.

#### **4.7 Learning from Fractals**

Fractals in small processes are reflecting the whole system. It is important to learn from the small for the big and from the big for the small. Fractals started to unveil information about the hidden nature of chaos and order in the universe (see BRIGGS/PEAT 1190, p. 152). Sustainable land management can therefore be seen as a fractal of a sustainable society that is aimed at. Therefore, we assume that we can learn from sub-processes of sustainable land management for the entire process of sustainable development. The knowledge gained from the fractal (sustainable land management) can be used to form strange attractors, to find information about new bifurcations and to use back coupling and intermittences in a better way.

### **5. CONCLUSIONS**

Complex systems – whether chaotic or organized – cannot be entirely analyzed. They also cannot be reduced to small parts of it, because due to iteration and back coupling they are reflexive. Every interaction occurs in a bigger system and the system as a whole is changing permanently including bifurcations and iterations (see BRIGGS/PEAT 1990, p. 221). Using the principles of chaos-theory for analyzing the mechanisms of sustainable land management makes evident, that it is not possible to make either prognoses about the trend, nor set up certain compulsory tasks, components or specific indicators because every land management process is unique. While it is not possible to make generalized statements about the contents of land management, it is however very well possible to give a general statement on the process of land management. By means of chaos theory it is possible to identify the critical points within land management processes. This theory also offers answers on how to deal

with such chaotic processes to bring them at least rudimentary in a controlled course: It has been shown that decisions within a planning process are equivalent to bifurcations in a chaotic process. That means that at the moment of any decision-making the process is directed towards a new unpredictable course. This course or direction of the process (e.g. its degree of innovation, its suitability to the local situation or the extent of sustainability), however, can be influenced by intermittences respectively creative environments (e.g. round tables, discussions, creative/visionary workshops, education/formation/information) and strange attractors (e.g. key-actors, visions, guidelines, funding). The process can (and should) also be stabilized by back coupling (e.g. monitoring).

In conclusion it can therefore be stated that by using a chaos-theoretical approach, improvements in sustainable (land) development can be achieved which mainly consist of a more sophisticated way of participation of all stakeholders.

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## **BIOGRAPHICAL NOTES**

The author is surveyor, having been working first as state employee in land development and surveying (1993 – 1995), later as research assistant at the Chair of Land Readjustment and Land Development at Technische Universität München (1995 – 2001). Since 2002 he is a permanent academic staff at that chair. He holds a Ph.D. in engineering sciences. He is a member of the working group “Land Management” of DVW (German Surveyors Association) as well as of the steering committee of the master’s program “Land Management and Land Tenure”.

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