Indicators and what else – emergent properties as touchstones for sustainability processes

Ulrike Bechtold [1)] & Harald Wilfing [2)]

1) Institute of Technology Assessment, Austrian Academy of Sciences, Strohgasse 45/5, A-1030 Wien, Austria; mail to: ulrike.bechtold@oeaw.ac.at

2) University f Vienna, Dept. of. Anthropology, Human Ecology Research Group, Althanstrasse 14, A-1091 Wien, Austria.

Abstract

During the last decades, the idea of sustainability has changed significantly, as well as the referring concepts. Rather simple concepts, like "goal-oriented" strategies, can easily be distinguished from more systemic approaches regarding for example "complex adaptive systems". Especially attempts referring to systemic approaches have to be based on normative categories in order to describe whether the behavior of a society is sustainable or not. In this context, sustainability can be described as a process, which deals with dynamic interactions between society and nature. Consequently, such conceptualizations of sustainability refer to certain methodologies, which must be capable of describing and analyzing (various organization levels of) human-environment relations and their intrinsic dynamics.

It seems self-evident that systemic, process-oriented sustainability concepts frequently base on complex scenarios in order to describe the interdependencies as realistically as possible. Drawing the - apparently - evidence based conclusion that such assumptions lead to the belief that the success (and explanatory power) of sustainability research primarily depends on the right selection of indicators, nevertheless seems to be only half of the story.

Dealing with "real world problems", it becomes obvious that there might be system properties, which cannot be caught by a priori defined sets of indicators. We will demonstrate that it is insufficient to explain such difficulties by merely blaming an inadequate selection of indicators. We think that systems that describe human-nature interactions often display "emergent" properties, which have to be recognized as special entities.

Key Words

Sustainability, Indicators, Systems theory, Emergent properties, Community approach

Introduction

Since the commonly perceived roots of the beginnings of the sustainability debate the concept of sustainability has seen considerable change (WCED, 1987; Sneddon et al., 2006; Kates et al. 2001; Brand, 2000; Grunwald & Kopfmüller, 2006). Comparably simple concepts such as goal-oriented sustainability (Diaz-Balteiro & Romero, 2004; Jansen, 2003; Lafferty, 2002; Tamiz et al., 1998; Dreborg, 1996; Robinson, 1982) can be opposed to more systemic attempts (Kemp et al. 2007; Rammel et al., 2007; Fraser et al., 2006; Mayumi & Giampietro, 2006; Rammel et al., 2004; Bossel, 2001; Gunderson & Holling, 2002; Holling, 2001; Kelly, 1998). The approaches for organising the world to generate sustainability-concepts are manifold and the respective sectors chosen as accurate as possible. A certain systemic view is also reflected within approaches that recognize the triple bottom line concept – or the recently developed four pillars of sustainability adding an institutional one (Keiner, 2005; von Hauff & Kleine, 2005; Spangenberg 2004). Nevertheless, some approaches remain in one sector, whereas others are trying to embrace the triple bottom-line or even go a step further. Such as the livelihood framework, which corresponds with the triple bottom-line, but moreover it identifies five elementary capitals: human, natural, financial, social, and physical (Campbell et al. 2001; Bebbington, 1999; Carney, 1998), whereas Bossel (1998) adds organizational capital. He emphasizes, that these compartments do not reflect a disciplinary but a systemic allocation (Bossel, 1998).

The recent shift of paradigms of (scientific) knowledge production (Weingart, 1997; Klein, 1996; Gibbons et al., 1994; Funtowicz & Ravetz, 1991;1993) questions classical scientific approaches and modes of knowledge production. These "new" paradigms often adopt interdisciplinary frameworks (Glaeser, 2002; Becker et al., 1997; Becker & Jahn, 1999; Latour, 1999), aim to consciously boost practical use and applicability of science for people and hence actively involve (affected) people in terms of transdisciplinarity (Balsiger, 2005; Young, 2000) This shift seems to be especially relevant and promising for sustainability contexts (Schramm, 2004), as people are "the substrate" in two ways: they are actors and affected individuals (Odling-Smee et al. 2003; Lalland et al., 1999). Although these debates are ongoing and an abundant variability of sustainability conceptualizations can be found, at least one aspect is subject to (implicit) consensus among scientists and practitioners: sustainability is perceived as a normative concept (Sneddon et al., 2006; Glaeser, 2002; Minsch et al. 2000; Norgaard, 1988). Sustainability treated as a normative concept is based on polarity: distinguishing the desirable (sustainable) from the undesirable (unsustainable) is the core attempt (Sneddon et al., 2006; Glaeser, 2002).

Valuation of societies' sustainability hence requires a context, which is anchored in time and space and is based on certain ideas of nature-society interactions (Schutkowsky, 2006; Boyden, 1992). Based on these theoretical assumptions (sustainability is normative and action based) it is evident that also certain methodological approaches have to be developed. Such methods ought to include the various organizational levels of human–nature interactions regarding their inherent dynamics (Berkes et al., 2003). Although it sounds quite sensible, this aim has to be considered a rather ambitious one. Yet on a theoretical level, these demands are still addressed in manifold discourses and in some cases, the viewpoints are even contradicting. As one example in the following we state the debate on strong and weak sustainability (Daly, 1999; Gowdy, 1999; Ayres et al. 1998) or the different approaches of "planners" as opposed to "searchers" in developmental cooperation contexts (Easterley, 2006; Kottak, 1991; Bell & Morse, 2006).

The heterogeneity of the sustainability debate in terms of the concept itself as well as its theoretical foundations might be interpreted twofold. On the one hand it can be regarded as a hint that due to the complexity of the issue addressed, only approaches taking systems dynamics into account (Gallopín, 2006; Gunderson & Holling, 2002; Checkland, 1993,1999; Holland, 1992; Waldrop, 1992; Forrester, 1987) can face real world problems, which are the substrate of (non-)sustainability (Mackenzie et al., 2006; Petts et al., 2006; Rittel & Webber, 1973). But nevertheless, also systemic approaches do consider the necessity of a certain reduction of systems (Fraser et al, 2006; Bossel, 2001; Kemp, 2007; Morse et al., 2001). In other words, a systems approach intends to investigate how far a complex (adaptive) system can be analytically alienated without loosing the specific systems properties due to ontological reductionism (Schizas & Stamou, 2007; Anderson, 2001; Mohamed et al., 1994).

On the other hand, the heterogeneity of the sustainability debate might contribute positively to the desire of measuring what is supposed to be sustainable. Hence it becomes a clear goal to develop/identify or use scientific methods and instruments (toolbox is a fashionable name for state-of-the-art scientific inventory) that can be applied in different places at different times to (correctly used) always produce substantial, reliable and of course comparable data. At the latest since the RIO summit, in 1992 (UNCED) (Wapner, 2003; Schnoor, 2003) a wide range of such attempts – namely the use of indicators and indices – have been and still are proposed (for an overview see e.g. IISD, 2007 Parris & Kates, 2003 or Moldan et al., 1997; for a critical examination of the applicability of the indices in policy contexts see for Böhringer & Jochem, 2007; Pezzey et al, 2006; Hanley, et al. 1999, Dobson, 1997).

Without claiming to give a complete reflection of the different facets present in the current scientific debate of measuring or quantifying sustainable development, the following two aspects shall be highlighted:

- Systemic approaches are connected to a certain reflection of the difficulties of reducing a system to its parts (subject to measurement) – this approach involves a sound and careful debate on indicators and their use (Reed et al., 2006; Fraser et al., 2006; Bossel, 2001; Bell & Morse 2003; Kelly, 1998).

- Reductionist approaches which do not so much highlight the systemic aspects of the issue at stake (not to say that they are neglected) discuss sustainability in the light of producing a minimum of significant variables (indicators). To (seemingly) increase their explanatory power variables are aggregated to characterize sustainability. Noteworthy are attempts to embrace sustainability in one single value. E.g. a cumulative sustainability percentage for nations is calculated in Phillis & Adriantiatsaholiniania (2001) or on company level Figge & Hahn (2005).

These two (assumed) positions, which undoubtedly reflect extreme interpretations, mainly focus on indicators and their adequate use. A systemic approach can hence be labeled as a rather careful one, with emphasis on participative strategies and transdisciplinarity and hence active involvement of stakeholders, politicians, experts and laypersons (Blackstock, 2007; Bell & Morse, 2006; Slocum, 2003; Pahl-Wostl & Hare, 2004; Crabtree & Bayfield, 1998; Swedeen, 2006; Halvorsen, 2006; Stenberg, 2001). Whereas the "reductionist" approach would be characterized as expert led and assuming linear cause-effect relations (OECD, 2001; Olewiler, 2006).

This heuristic dichotomy is reflected by Fraser et al. (2006:114&115) who refer to it as "bottom up" versus top-down" approach. Clearly, this discourse is very important and of utmost value for clarifying sustainability issues. A fact that is also reflected by the controversial discussion that emerged in response to the recent publication of "Useless Arithmetic. Why Environmental Scientists Can't Predict the Future" by Orrin Pilkey & Linda Pilkey-Jarvis (2007) (Pielke, 2007). Nevertheless, we state that this very discourse has the potential to mask another crucial issue, which appears as soon as systems thinking is taken seriously in the light of sustainability. Based on results of a case study in Northern Peru we want to demonstrate that there are features, which may not be identified by a-priori sets of indicators. Further we emphasize that this problem is not a problem of using the wrong indicators but a systems problem: systems properties may be emergent properties and therefore, they may not be detected on the level where they are caused (Corning, 2002). Nevertheless, or precisely for this reason, such emergent properties may be crucial touchstones for sustainability processes (Gunderson & Holling, 2002).

Tombs with a "systemic" view

The reason why a small remote Peruvian village named Leymebamba gets the world's attention in 1997 is described in the publication titled "Tombs With A View" by Adriana von Hagen and Sonia Guillén (1998). The *distrito Leymebamba* lies in the *departamento Amazonia* in the North-East of Peru – and is located at the eastern rim of the Andean Cordillera characterized by cloud forest and a rather humid climate. *Leybembamba communidad campesino* has a somewhat urban center (situated at 2238 m.a.s.l.) counting about 1900 inhabitants; another 1700 people live in nine so-called Anexos which are small rural settlements within a radius of max. 25 kilometers air-line distance (Caritas del Peru, 2004). To illustrate the remoteness of Leymebamba, in the following we will list some minimum travel-times at best weather conditions: from Leymebamba: to Chachapoyas, the provincial capital and closest urban commercial center - 3h; to San Pedro Riuz, beginning of the paved road – 7h; to Lima – 23h.

The most dominant economic sector is a quite typical mode of agriculture in so called Chacras – which are patchy farmlands in the surrounding mountainous areas reaching from lowland rainforest (approx. 800 m.a.s.l.) up to the Altiplano-highlands (approx. 3800 m.a.s.l.). The traditional local Chacra agricultural system is, concerning some main features, such as manual erosion treatment, comparable with the typical historical European Alpine farming system (McC. Netting, 1982, 1993; Viazzo, 1989). The agricultural production is very work-intensive and the land tenure system is characterized by a small amount of landowners who employ farm workers, called "Chacristas". They often live in the Chacras and are in charge of the fieldwork as well as of the regular transport of agricultural and dairy goods on mule tracks and steep trails. Due to the geographical location, near the equator, a broad range of agricultural products are cultivated throughout the year (in 2003: potatoes: 510ha; beans: 265ha; corn: 65ha; grains: 12 ha, yucca: 19 ha) as well as livestock farming (2003: about 12000 cattle were kept in the Chacras producing about 19000 tons of milk) (Caritas del Peru, 2004; FONCODES, 2000).

As mentioned above, in 1997, Leymebama was affected by an extraordinary incident: at a distance of about 15 hours trail-march from Leymebamba, at the Laguna de los Condores, an almost untouched Chachapoya necropolis was fortuitously discovered by some "chacristas". The Chachapoya-culture was a pre-Columbian, pre-Incaic local culture, located in latter-day northern Peru between approx. 800 and 1500 AD (Muscutt, 1998; González & León, 2002). The necropolis of the Laguna de los Condores quickly received worldwide attention: besides numerous archaeological findings about 210 well preserved Chachapoya-mummies could be retrieved. Although it was already known that also the Chachapoya used to entomb their corpses

within a bundle of fabrics, only few of these mummy-bundles outlasted the centuries, mostly because of the adverse climate conditions but also due to robbery ("huaqueo") or vandalism[1]. Therefore, it is not surprising that soon after the discovery several TV-stations as well as journalists hit the arduous road to Leymebamba and the small, remote village caught a glimpse of the world's attention.

However the Chachapoya mummies of Leymebamba can be designated notable due to another reason. Generally all Peruvian archaeological findings have to be handed over to the national conservation authorities (Instituto Nacional de Cultura, INC), who furthermore are responsible for their conservation and regular custody. Customarily the INC uses the central national museums suited for this purpose. But the findings of Leymebamba were handled differently. The local INC authorities decided to leave the mummies in Leymebamba also because institutional, national and international as well as private interest was high. The entities involved also donated enough money to build a local museum. In the year 2000 the Museo Communitario Leymebamba was opened.

One of the declared goals of the donators and the administration of the museum was to dedicate the mummies and the archaeological findings to the people of Leymebamba. By conserving the remains of their ancestors a reference to their cultural identity should be established. The hereby intended process to empower the remote local community so far offered several educational activities concerning mainly conservational-ecological issues in terms of habitat protection. These processes were also accompanied by a project conducted by the authors in the name of the Human Ecology Research Group at the University of Vienna, Austria (Bechtold et al., 2006; Wilfing et al. 2005; Bechtold, 2006). The overall aim of that study was to identify potentials as well as obstacles of local sustainability processes within the socio-ecological system "Leymebamba" (Bechtold, 2006).

Remoteness in transition to sustainability

The discovery and the presentation of the Chachapoya findings affected the socio-ecological system of this remote village in many ways. Overall we refer to these powerful developments that affected the community as impact. This impact caused significant changes and generated eligible

[1] The discovery was owed to several reasons, one of which is the beneficial microclimate of the tombs under a waterfall (over the centuries) – the falling water caused a very dry climate in the tombs behind. Due to lacking rainfalls, (some say that local deforestation has diminished the annual precipitation) in 1997, the waterfall changed to a small rill and shed light to the tombs.

perspectives and claims as well as new problems and worries within the community of Leymebamba. These positive and negative perceptions were subject to the analysis and basis for developing a heuristic framework, which then was used for a process towards the identification of local perspectives of sustainable development.

The underlying concept of sustainability is derived by Paehlke (1999) and Lucas (2000) who conceive sustainability as a place based societal process of learning, seeking and creating, which is always coined by conflicts, uncertainty, lack of knowledge and tensions. Concerning the composite term of sustainable development we refer to Holling et al. (2002), who describe sustainability as:

"the capacity to create, test, and maintain adaptive capability. Development is the process of creating, testing, and maintaining opportunity. The phrase that combines the two, sustainable development, is therefore not an oxymoron but represents a logical partnership."

Holling et al. (2000:76)

After a clear fallacy of the transfer-paradigm of knowledge, technology or matter sustainability addresses the enlargement of societal ability to develop (Bossel, 1998) and the necessity of embedded empowerment (Leiserowitz et al. 2004). Sustainability hence should open prospects and not prescribe clearly defined outcomes.

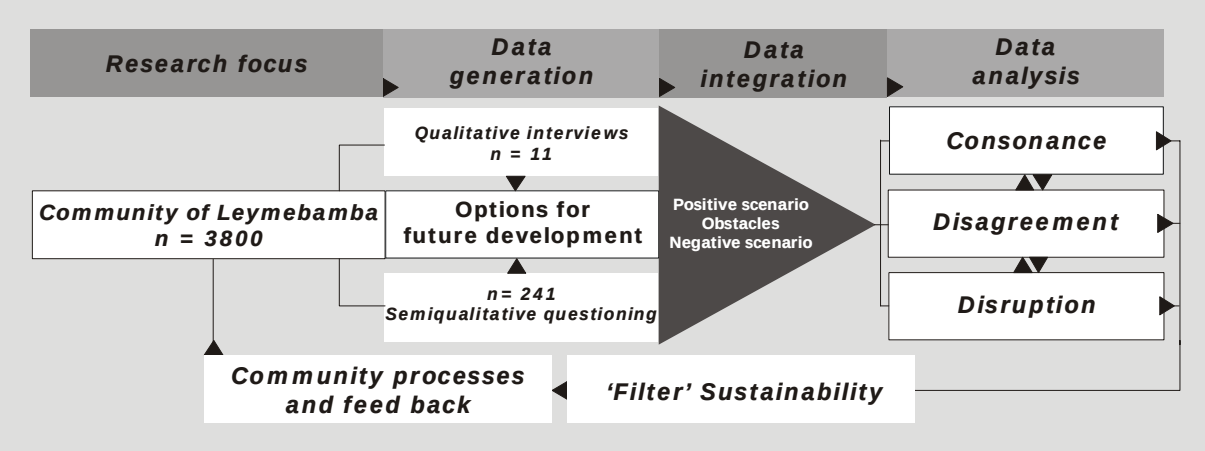

Figure 1: General research approach of the Leymebamba case study.

Figure 1 gives an impression of the general research approach, based on the conceptualization of sustainability mentioned above. Its major essence was the combination of stakeholder- and expert-interviews with a randomized survey using questionnaires. The results of both, qualitative interviews as well as semi qualitative questioning, produced data in terms of a broad variety

concerning options for future development in Leymebamba (Ratner, 2002; Mayring, 2001, Kelle, 2005). The data integration, then allowed identifying a certain structure within these options and the following data analysis enabled the detection of consonances, disagreements and disruptions (Denzin, 1989). The final feedback-processes should mainly provide a basis for the communal discussions of development opportunities and their potential for local sustainable development (Leitbildprocess e.g. Valtentin & Spangenberg, 2000).

This rather open research design and the derived widespread results also enabled a systemic conceptualization of the result. Therefore, we developed a heuristic framework which gives a systemic impression of the main elements and identifies some major positive and/or negative driving forces in terms of feed-back loops. This also served as a heuristic device of the socio-ecological dynamics of Leymebamba and was used as a basis for the above mentioned communal processes. Figure 2 shows the main elements of the "system Leymebamba" emphasizing only the polarities of the spectrum of ideas, wishes or concepts that were found within the sample. For the results of the in-depth analysis and visualization of the system Leymebamba see Bechtold (2006) and Bechtold et al.(2006).

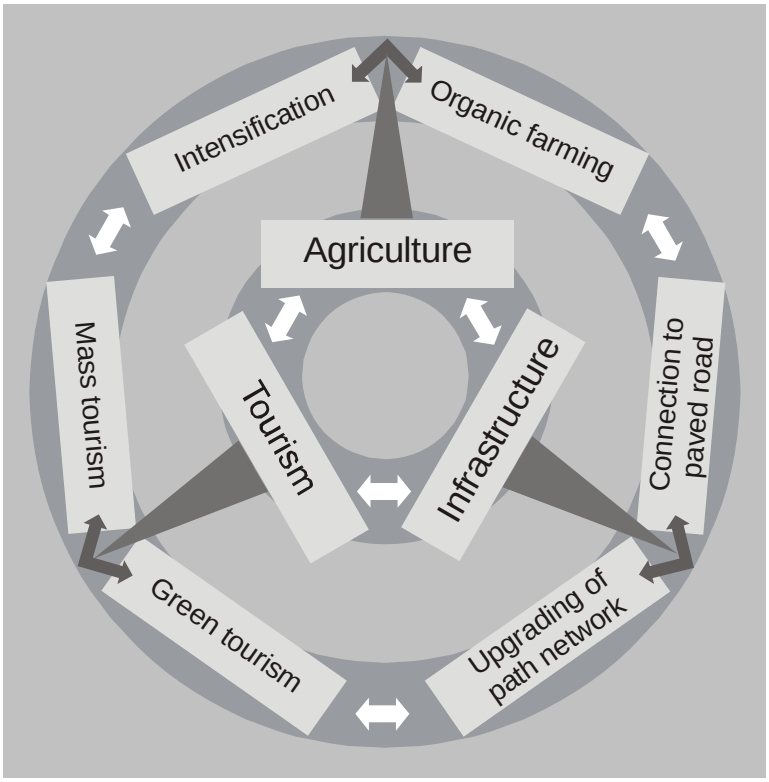

Figure 2: Characteristics of the "system Leymebamba". Inner circle: main elements; outer circle: polarities of the spectrum of ideas, hopes and concepts for a future development.

To illustrate the high interdependencies between the elements we want to explicate the perceived polarity of Infrastructure as shown in Figure 2: upgrading of path-network versus connection to paved road. The latter is meant in terms of paving the main road from Leymebamba to San Pedro Ruiz to shorten the driving time and facilitate tourist access as well as improving the market opportunities for agricultural products. The former polarity refers to the improvement of the local net of paths and trails in terms of facilitating tourist access to the archaeological sites. Surprisingly this request is not referred to agricultural use – in other words the future is seen with the eyes of a tourist rather than of a *chacrist*.

Generally it is not very surprising that infrastructure, agriculture and tourism are the main elements of the system Leymebamba. Any person knowing the region or involved in developmental cooperation could say so, after spending a few days there.

The identification of these elements as the working areas for triggering local sustainability processes raises the question of how to capture them. The use of indicators is a proximate answer. And for all three of these elements adequate indicators can easily be defined. Because we referred to the polarities of infrastructural aspects earlier Table 1 gives a more detailed overview of some indicators. For Agriculture (Cauwenbergh et. al, 2007; Roldán et al., 2007; Hansen, 1996; OECD, 2001) and for tourism such frameworks can also easiliy be found (Hunter & Shaw, 2007; HwanSuk & Sirakaya, 2006; Miller, 2001).

The application of these or similar indicators and/or indicator-sets undoubtedly can generate adequate results describing the status quo and also being capable of monitoring changes if goals, thresholds or limits were negotiated in participative processes (Blackstock et al., 2007; Bell & Morse, 2006; Gehrlein, 2004; Valentin & Spangenberg, 2000; Meadows, 1998; Renn et al., 1995). At this point one could say the important elements are identified, a series of fitting indicators are found (eventually and worthy; they should also be chosen specified by a participative process). Nothing seems to hinder a successful monitoring towards sustainability.

But why such fuss then about systemic views and power of indicators? Without being biased - or fixated on indicators – looking at the data obtained, another outcome appeared. Surprisingly this did not fit at all with the elements mentioned above (see Figure 2).

It is what we called "communal particularism" (CP). Something which the respondents in the interviews referred to by using different names: "peculiarity of people", "local idiosyncrasy" or a "strong dominance of individual interests", "selfishness" or "fraud amongst brothers" to mention only a few of them.

Table 1: Some exemplary indicators for the main element infrastructure of the "system Leymebamba".

Indicator - Framework and Source	**Reference levels**	**Selected exemplary Indicators**
Proposed TERM Indicator List (Transport and Environment Reporting Mechanism) EEA, 2002	Environmental consequences of transport Transport volume and intensity	- transport final energy consumption and primary energy consumption, and share in total (fossil, nuclear, renewable) by mode - transport emissions and share in total emissions for CO2, NOx, NM, VOCs, PM10, SOx, by mode - exceedances of air quality objectives - exposure to and annoyance by traffic noise - infrastructure influence on ecosystems and habitats ("fragmentation") and proximity of transport infrastructure to designated sites - land take by transport infrastructures *Passenger transport (by mode and purpose):* - total passengers - total passenger-kilometers *Freight transport (by mode and group of goods):* - tonne-kilometers per capita - tonne-kilometers per GDP
Rural Roads Vulnerability Reduction Assessment Keller, 2002		- roads located in vulnerable areas (on landslides, in floodplains, on steep slopes, etc) - frequent need for road maintenance - damage or needed repairs from small storm events - undersized drainage structures - critical transportation links between communities or areas
Land use & transport system characteristics in lower income regions Kenworthy & Laube, 2002	Land Use & Wealth Private Transport Infrastructure Indicators Public Transport Infrastructure Indicators Private transport supply (cars & motorcycles) Traffic Intensity Indicators Public Transport (Supply & Service)	- total length of reserved public transport routes m/1000 persons - passenger cars per 1000 persons - overall average speed of public transport (per means of transport) - ratio of public versus private transport speeds
Sustainable Transportation Performance Indicators Gilbert, et al, 2002	Environmental and Health Consequences of transport Transport activity Land use, urban form and accessibility Supply of transport infrastructure and services Transport expenditures and pricing Technology adoption. Implementation and monitoring	- total motorized movement of people - total motorized movement of freight - share of passenger travel *not* by land-based public transport - movement of light-duty passenger vehicles - index of relative household transport costs - index of relative cost of urban transport
Sustainable Mobility Indicators Eads, 2001	User concerns Societal concerns Business concerns	- safety (number of death and serious injuries - security (chance of user being subject to robbery, assault, ect.) - CO2 equivalents, Voc, PM - noise - potential for generating government venues

In the questionnaires CP also appears as Figure 3 shows. Here the informants could make free associations – concerning amongst others[2] negative developments for the village Leymebamba. 75% out of these statements refer to a kind of social disintegration ("lack of values and beliefs",

[2] One part of the questionnaire asked respondents to associate freely: three items each participant was assigned to in terms of 1) a positive, 2) a negative future development of the village Leymebamba as well as 3) perceived obstacles to positive future development.

"disapproval of alcoholism and nightlife", and "CP"). This is regarded as a strong hint for the force of CP in the "system Leymebamba".

The phenomenon of CP can be seen as a specific condition of the social system opposing the "social and cultural imparative" as proposed by Robinson & Tinker (1995:19). According to Simon (2004) it can be called an unsatisfactory synchronization of communication and/or a poor balance: normally communicating participants (humans, social units) of social systems start from different positions, have different backgrounds and aim for different goals. Their seemingly opposing positions adapt to each other within a self- organizing process.

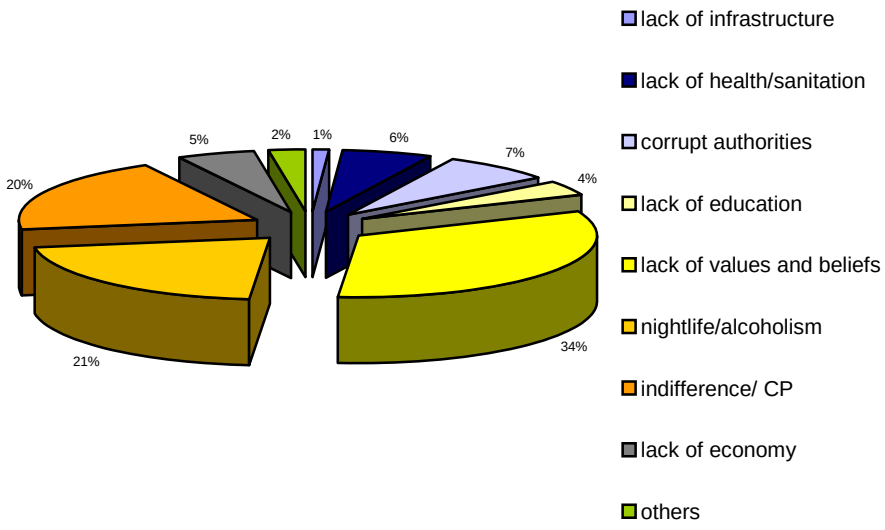

Figure 3: Negative scenario – first entry (n=206).

The next step is to clarify whether the phenomenon of CP is another element in the "system Leymebamba" or not. Based on the results presented so far one would hastily have to admit: yes. Consequently, we assume that examining CP similarly to the other elements of the systemic overall picture (Figure 2) should work. Therefore, presumably the application of indicators could capture CP.

It is well known that e.g. the social aspects of sustainability are subject to so called social indicators. Various respective frameworks embrace social integration and disintegration (Putnam, 2001; Empacher & Wehling, 1999; Meadows, 1998; Diefenbacher et al. 1997; Hardy & Zdan, 1997). Also the theory of social capital proposes that confidence as one aspect of social capital increases proportionally to voluntary activities of people. A result which describes this feature in Leymebamaba might be memberships in a committee, association or other club found within the

sample, which were considerable high at 32,7%. Nevertheless, the phenomenon of CP can be seen as an antagonist force.

Taking a closer look at social indicators the meaning of indicators which is according to Litman (2007:3) defined as *„A variable selected and defined to measure progress towards an objective"* has to be widened. Social indicators are more than values, as Bossel (2001) and Meadows (1998) have previously stated, they have to account for the subjective, too. Taking the social impact assessment literature into account (Vanclay, 1999, 2002; Gramling and Freudenburg, 1992; Armour, 1990), it becomes evident that social impact analysis requires a rather systemic approach: *"Because of the existence of second- and higher-order impacts, the complex iterative processes by which impacts are caused, and the complex impact pathways and causal chains, a thorough analysis using the conceptual framework [...] is advocated."*

(Vanclay, 2002:208).

Measuring the immeasurable or the "screwed astronaut"

Assuming it can be stated: agriculture, tourism, infrastructure and CP are the main elements within the system-dynamics in Leymebamba. They can be recorded by applying adequate indicator sets. Actually at this point the experts can pack their bags and leave the community, who (as we hypothesize) have learned what is of importance and how to measure and monitor these issues in terms of sustainability (Hart, 1997). Remembering the underlying understanding of sustainability mentioned above (Leiserowitz et al., 2004; Holling et al., 2002, Lucas, 2000; Paehlke, 1999) we have to come up once again with the implication that local sustainability processes cannot merely operate with clear goals but also have to be seen as opening the process for the unknown. Additionally, the critical perspective of what sustainable development means within developmental theory and developmental studies has to be considered here:

"With respect to "development as a rocket", [again,] the metaphor is left unquestioned; rather the speed and direction of the rocket are discussed, and policies that operate within this metaphor are adjusted in this fashion."

(Pretes, 1997:1428).

The critique of Pretes (1997) concerning the sustainability debate[3] can also be applied here: taking a closer look at the four elements describing the system of Leymebama by means of indicators such an approach would merely address the speed and the direction of Pretes' rocket and would not question the rocket itself as a means of transport. Staying within this metaphor CP can be assigned the role of a "screwed" astronaut navigating the rocket. The apparently meandering course of our rocket (driven by CP) can be referred to as systems "on the edge of chaos", well known as complex adaptive systems (CAS) (Rammel et al. 2007; Ramos-Martin, 2003, Waldrop,1992; Holland, 1992; Arthur et al., 1997).

Throughout the underlying case study Leymebamba was seen as a CAS. Therefore, the elements tourism, agriculture and infrastructure had to be distinguished from CP. Because CP is found a force ***within*** all elements. Therefore, it affects all aspects within the remaining three elements that are important for any sustainability-process – and as long as CP is not explicitly taken into account and faced as a force – it will affect all sustainability processes in a completely unforeseeable and most likely negative way. Therefore CP can be seen as an emerging property of the "CAS Leymebamba" which can not be measured/captured on the level where its constituting properties lie (Schurz, 2006; Corning, 2002, Holland, 1998). But this is exactly what social indicators would do: they would remain on the level of their manifestation – without applying a systemic view (Vanclay, 2002,1999). Hence they are not capable of drawing a picture of what CP is or might be.

The complete narration of the case of Leymebamba as sketched above was built upon a systems background and is based upon various applications of the general assumptions of systems theory (Bechtold, 2006; Schurz, 2006; Simon, 2006; Berkes et al., 2003). This (sometimes implicit) foundation of the narration now turns out to be an indispensable precondition: As a matter of fact only the systemic view allowed to work out the difference between the elements of the system and the emerging property of CP. CP and its appearing varieties can be assigned to be a systems quality or an emerging property rather than a systems element. As such CP and its activities can not be defined or captured by any indicator (set) defined a-priori. So the seemingly correct conclusion drawn above, that CP might be captured (a-priori) by a set of social indicators must necessarily fail. Capturing CP (or better its emerging varieties) by means of indicators is only possible as an a-posteriori application of an analysis of the village as a system.

[3] This critique refers to growth as the dominant and unquestioned concept of development. In the developmental context the growth paradigm is also thoroughly critisized e.g. by Cavalcanti (2006) and Davison (2001).

Arriving at a "fragmentary" synthesis

Consistent with the broad and comprehensive sustainability debate, as outlined in the introduction, the following attempts will have to remain fragmentary. Nevertheless, some essential thoughts shall be presented taking into account that other important aspects will have to be left unmentioned. First of all, this case allows the general assumption that the identification of emergent properties (e.g. CP-borne community characteristics) might be crucial for all facets of local sustainability processes. According to Pfeifer & Scheier (2001) emergent properties are given the following meanings: (1) something surprising and not fully understood, (2) a property of a system that is not contained in any of its parts, and (3) an unforeseeable behavior, that arises from agent-agent and/or agent-environment interactions. Therefore, emergent properties elude a perceptibility without systemic approach (Buenstorf, 2000). Nevertheless, emergent properties are of crucial interest for any analysis in terms of action, as they cannot be predicted by analyzing each element of the system (Schurz, 2006; Simon, 2006; Corning, 2002; Bertallanffy, 1968).

Hence, only systems thinking is suited for tackling local sustainability processes without being deterministic. Sustainability issues are always concerning and including different paradigms, policies, values and worldviews. Moreover different people, communities, parties, interest groups etc. are involved as actors (Simon, 2004; Bossel, 2001). A model of sustainability hence relies on using a heuristic device including different tiers – however they are labeled. Provokingly, one could say that once the scientist is caught in the (successful and data producing) process of "measuring sustainability" it is certainly rather tempting and somehow even inherent in the process of measuring itself that the scientist develops or (unconsciously) deploys a clear state to be reached – which then is regarded as sustainability. But what is measured sometimes remains limited to different numbers for each tier examined. Such attempts can be compared to a well-known phenomenon that you only define what you measure by the process of measuring itself (Pöppel, 2006; Tremmel, 2003) leading to the operational definition that "sustainability is what the sustainability indicator measures" – which indeed represents a fallacy.

Sustainability itself - justly tagged as something "ambiguous, normative and contestable" (Davison, 1999:43) has to be negotiated and defined by each affected community anew (Meadowcroft, 1997). Hence, it is necessarily bound to communities and action and far from being a tangible concept to be expressed in numbers. But even if we imagine knowing which number could be associated with sustainability, we can still ask if communities are to be indexed with numbers in order to legitimately say something about their sustainability? This is certainly even more evident if communities are regarded as complex adaptive systems – in which the

actors interact, and mutually influence their perceptions, values, desires and actions. The major problem with indicators is the fact that a rather static measurement is applied to a dynamic object of interest. But the entire dynamics that can be gained using indicators refers to a certain quality of history – the one that is usually captured applying time series. This has to remain an artificial sort of dynamics (Bossel, 2001). Either the object of interest is shaped and not called (un)sustainability or the methods of measurement are adapted.

One option of adapting measurement is seen in applying a systems analysis before choosing indicators. For this purpose e.g. Soft Systems Modelling (SSM) according to Checkland & Poulter, 2006; Checkland, 1999, 1993) seems suitable. SSM does not aim at depicting reality (or the system at stake) as an end in itself, but at providing a basis for discussion. In our case such a representation served as a "systemic basis" for communal, participatory processes. Thereby emergent properties relevant to community processes receive the attention required before generating goals for sustainability.

The importance of knowledge about the local context before applying any measures is widely recognized (Turnhout, 2006; Fraser et al. 2006; Cavalcanti, 2006; Morse et al. 2001; Bossel, 2001, Kottak, 2006). Therefore, the local context gains importance although as Reed & Dougill (2003) assert in terms of a trade-off that there is always a choice to be made between applicability and comparability. They propose a local development of indicators at the very level of actors involved – whereas a close linkage between local and scientific knowledge is regarded very important, as well as an overall participatory approach (Reed et al. 2007; Fraser et al., 2006). This approach is promising as shown in several case studies (Fraser et al., 2006). Although the overall purpose of this approach seems rather focused on identifying and applying adequate indicators, they emphasize the importance of „[...] using local knowledge as a starting point in research [...]" (Fraser et al., 2006:120).

Again the local cultural context is key for bringing theory into practice (Slootweg et al., 2001; Checkland, 1998; Kottak, 1991, Kottak & Colson, 1994). This inclusion takes place by raising two questions: what is perceived to be of importance and how is it judged? And it takes into consideration that these issues might change. Both, in terms of the items themselves and in terms of how issues are estimated by people. Following Checkland (1999, 1993) this is about constructing reality rather than about depicting it (Glasersfeld, 1997).

Conclusions

Assuming the results of the Leymebamba case study it became evident that social systems in terms of CAS might display system properties, which cannot be caught by a-priori defined sets of ecological, economic, institutional and/or social indicators. But these emergent properties can become crucial as hidden forces. Any local (sustainability) initiative should therefore be aware of the fact that occurring concerns might be emergent properties in the sense of systems theory. Hence, only a systemic view will be capable of identifying these exceptional entities. Indicators can be applied meaningfully and produce relevant data if it is clear whether they rely on a systems element, the system dynamics or on an emergent property. The last application has to be handled with particular care because the results produced can only refer to the tip of the iceberg. Hence, all interpretations based on such measurements are doomed to failure. In the context of sustainability as a normative concept related to action, the awareness of this problem is the touchstone. Moreover, it is important not to remain on the level of systematizing. The attempt to organize the world and its real problems has to be overcome by crossing the border towards a systemic approach.

It is important to emphasize that taking a closer look at the power of indicators does not at all mean that quantification (by indicators) itself is the problem. Indicators are essential tools. Only the scientist's expectation in terms of their explanatory power to measure sustainability is at stake here. Although already the conceptualization of sustainability remains rather disperse, we do not want to boost the "cloudiness" of the concept by using rather "cloudy terms" such as "dynamics, systems, systemic, emergence". On the contrary, as Gordon (2007:143) states: *"Perhaps there can be a general theory of complex systems, but it is clear we don't have one yet. A better route to understanding the dynamics of apparently self-organizing systems is to focus on the details of specific systems."* This point of view can be supported by the understanding that complexity is the third veritable pitfall for the human mind besides quantum physics and the theory of relativity (Schurz, 2006). Conceptualisations of sustainability operationalize real world problems. Local sustainability processes base upon these conceptualisations. They are applied to reduce the complexity of the real world to measurable levels. This is a tricky pathway, because complex reality is likely to be mixed up with the limitations of the underlying operationalizations. If this happens the real world and its complex interdependencies are in danger of being excluded a-priori.

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