An Integrative Systems Methodology for Dealing with Complex Issues

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Abstract: The purpose of this contribution is to help readers understand and respond to the need for multi-methodological approaches to dealing with complex issues. The synthesis of quantitative and qualitative methods is demonstrated by means of a case study. The case studied is about a large systems analysis with surprising, far-ranging effects in the real world. In the light of broader empirical evidence, the insights from the case are finally elevated to a methodological and then epistemological level: A framework for an Integrative Systems Methodology is presented.

1. Introduction

This contribution is a plea for multi-methodological approaches to problem-solving. It is meant to help readers understand the need for combining methods when dealing with complex issues and show them a path toward pertinent applications of this idea.

The argument rests on a systemic view, i.e. a perspective grounded in the Systems Approach, namely System Theory and Cybernetics. System Theories are formal theories for the description and explanation of organized wholes (e.g., von Bertalanffy 1968, Rapoport 1986). Cybernetics is a science of (self-) control and communication in complex dynamic systems (Wiener 1948). We are following the Systems Approach here for at least two reasons. First, it provides a formal apparatus which helps understand dynamic systems (e.g., Forrester 1968, Sterman 2000). Second, it makes available conceptual frameworks (e.g., Ackoff 1981, Rüegg-Stürm 2005) and heuristics (e.g., Schwaninger 2004, Ulrich 2001) for dealing with organizational complexity.

The concept of multi-methodology has been illustrated in the literature by many case studies (e.g., Mingers & Gill), but it has not been explored in depth: There has been little discussion about generic lessons from combining methods in practice (Howick & Ackermann 2011).

This contribution helps to close the gap. It builds a bridge between the practice of applied research and a methodological and epistemological perspective. First, a sophisticated exemplar of multi-methodology is presented. This has been distilled from many

comparable cases studied by the author and his doctoral students. From these studies, a new conceptual framework, termed *Integrative Systems Methodology*, emerged. That framework is presented in the second half of the chapter, with ensuing final conclusions.

2. The Case of Gastein Valley

The purpose of this case study is to present an exemplar of a complex project in which different methods had to be combined for an effective solution to a difficult problem at hand.

The Gastein Valley (Gasteinertal) in the county of Salzburg is a lovely spot, and one of the top tourist regions of Austria. Located at the rim of the alpine Tauern Mountains, it is connected to the north and the south via a railway coming from Salzburg in the north and continuing southward to Villach. The mountain is traversed by a tunnel leading from Bad Gastein to Mallnitz (Figure 1).

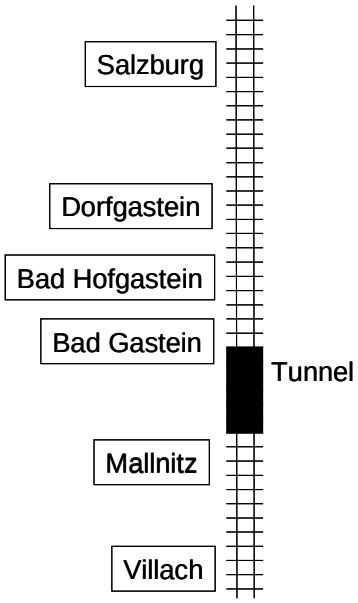

Figure 1: Train connections to the Gastein Valley

At the end of the Millennium, the Austrian state decided to build a fast railway transversal across the Alps, leading through the Gastein Valley and opening a high-capacity connection along the north-south axis Salzburg - Villach, which would also open links towards Italy (Udine) and Slovenia (Ljubljana). This was a mandatory project, directly derived from the membership contracts of Austria with the European Union (European Union, 1994).

The project would include a new layout of the line as a heavy-duty track with two roadbeds, instead of one as in the past. It was foreseeable that such a project would have decisive consequences for the Gastein Valley. The new infrastructure would create large additional capacity which would imply the potential for a huge growth of traffic on that route. In relation to current transit frequencies, the new capacity would amount to a foreseeable growth of 600 to 700 percent.

In the whole county of Salzburg and especially in the Gastein Valley, tourism is a very important economic factor. More than 30% of the work force of the Valley were employed

by the hospitality industry. 60% of all jobs in the area depended directly or indirectly on tourism.

Bad Gastein is one of the foremost traditional health resorts. Since the middle ages it hosts health tourism, and it has been an official spa since 1807.

The Gastein Valley is highly attractive, in particular for health-oriented types of tourism. What is the core competency of the valley? It offers comprehensive prerequisites for people to obtain health and regeneration. Many of these market segments, such as health vacation, fitness vacation, rehabilitation and cures, were growing in the target markets, particularly in Germany.

In sum, the following critical success factors for the Gastein Valley destination were identified:

- Nature
- Health resorts (thermal radon springs and radon gallery, - largest natural inhalatorium in the world)
- Quietness / absence of noise
- Beauty of landscape and settlements
- Tourist infra- and superstructure
- Socio-cultural factors, hospitality in particular

At the outset, the Gastein Valley was located in a virtually transit-free zone. The high volumes of transit were absorbed by the Felbertauern tunnel to the west and the Tauern highway to the east. This balance would completely change with the construction of the high capacity rail route. The levels of increase in both emissions and immissions would depend on the technical solution, i.e. the chosen construction variant. A circumvention of the project was out of discussion, as the EU contract was a fact.

Since the beginning of the planning phase in 1989 until the opening of a mediation process in 1998, two camps confronted each other implacably. On the one hand, a group around the Austrian Railways (ÖBB) and the Ministry of Transport, Technology and Innovation favoured an open (uncovered) and thereby less expensive track layout arrangement. On the other hand, a group of citizens together with institutions related to the local tourism industry demanded a completely closed and therewith immission-minimal variant.

There was an urgent need to resolve this conflict and eventually to move toward a consensus in order to reach a sustainable solution. This led to the initiation of a mediation process.

The mediation forum was constituted by representatives of a number of organizations[1] or functions, namely

- An initiative of local citizens
- The local authorities from the communities of the valley
- Authorities from the county of Salzburg

[1] The elaboration of a written mediation contract („Mediationsvertrag“), as defined by Austrian law, was the goal of the forum. Such a contract would condense the final outcome of the project, i.e., the decision taken by the forum, and be binding for both the governmental and the civil parties. The document would be presented to the federal authorities.

- Austrian Railways (ÖBB)
- Ministry of Transportation, Innovation and Technology
- Austrian Alpine Association (Ö.A.V.) - Section Bad Gastein
- Civil Engineers
- Environmental attorney

The forum decided to schedule regular sessions and to form task forces around core issues: Ecology, noise, engineering, legal issues, etc.

The analysis made progress, but a synthesis of the many partial aspects was still missing. Such a synthesis was necessary to serve as a foundation for the decision process. In early 2000 I was asked by the mediation forum to carry out a study. I offered to work out a system study in cooperation with Dr. Christian Laesser, the deputy director of the Institute for Public Services and Tourism, an expert on transportation and regional economics. We were put in charge and also offered all the resources available in the mediation forum. This included both the expertise of the citizens and specialists[2] involved in the project, and the many specialized studies and reports they had accumulated until then.

The decision that the construction of the High Capacity Railway (HCR) would be undertaken was definite and unquestionable, because it derived from a contractual agreement between the Republic of Austria and the EU (see above). The question, therefore, was not whether the intrusion should be carried out, but which one of the possible variants considered for that interference was to be realized. This study was meant to help the forum in taking its final decision.

The approach of the system study we envisaged had important implications:

- The study had to assess not only the economic effects of the planned intervention, but the social, technological and ecological aspects as well.
- It had to take into account the interrelationships between these different components (economic, social, ecological) considered.
- It had to be dynamic, i.e., a static "photograph" of the situation after the interference, compared to the conditions at the outset, would not suffice.
- It should incorporate not only analysis but also synthesis in order to provide a comprehensive picture.

I cannot refer in detail the works undertaken, e.g., on-site-inspection, the study of documents, etc. Here I will concentrate on the models which emerged in the process.

We proceeded to a situation analysis. This included an examination of the contextual factors of transport policy, tourist trends, Gastein Valley as a destination, tourism assets, tourist demand, core competencies and critical success factors.

This analysis allowed us to operationalize and specify the conceptual scheme (Figure 2), with a view to framing the further steps of the study.

[2] This included many experts who were not members of the mediation forum, but were contracted for specific assessments of, e.g., technical, ecological and legal aspects.

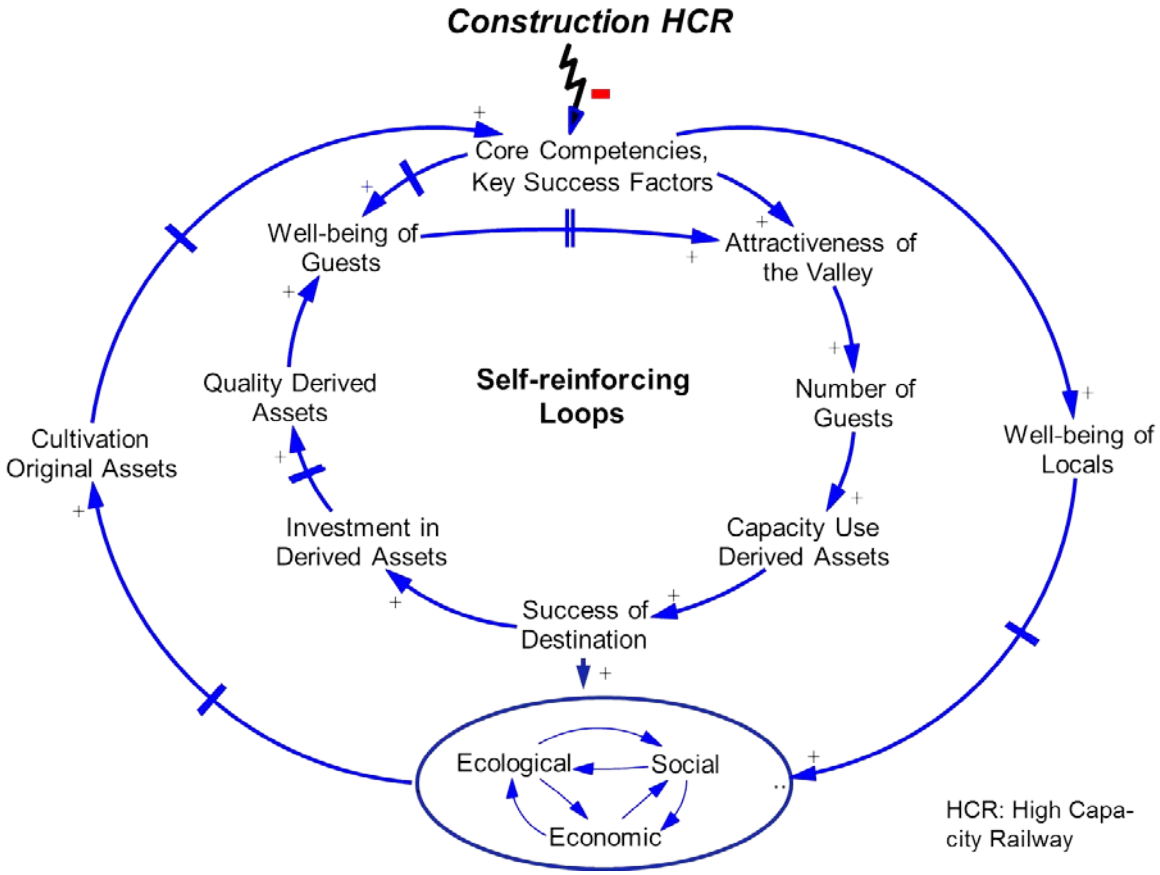

Figure 2: Causal loop diagram.

The representation used in the diagram is a common feature of qualitative System Dynamics. While issues of the type studied here are usually represented by means of open causal chains, we favor the approach that relies on closed loops. These capture a characteristic feature of complex systems: Feedback loops, i.e., the causal connections leading from a variable back into itself.

The construction of the High Capacity Railway was the initial shock. It would shatter the core competencies and critical success factors of the valley. From there we went on to identify causal chains which then would become the object of more detailed studies. Two self-reinforcing loops emerged:

The inner, primary attractiveness loop shows the influence of key variables of the original environmental package or set-up, namely landscape, nature, quietude, beauty of villages and cultural conditions. These variables, by and large, determine the well-being of guests and (in part directly, in part indirectly via the well-being of guests) the attractiveness of the valley, which is decisive for the number of changes in the number of guests. The capacity use and the economic success of the destination (both measurable in hard figures) would change as well. These changes would have consequences for the investment and thereby for the evolution of the quality of the derived set-up (infra- and superstructure). Because that very quality again impinges on the well-being of guests and the attractiveness of the valley, the loop is closed.

The outer, secondary loop builds itself around the local context of the valley – its ecological, socio-cultural and economic dimensions. On the one hand, this context is

coined by the well-being of locals. On the other hand, it is influenced by the success of the destination.

Via the variable *cultivation of the original assets* the loop is closed at the juncture with *critical success factors*. The picture then shows two self-reinforcing loops.

This causal diagram pictures the dynamics generated endogenously. In System Dynamics this is called to the fore in comparison with exogenous dynamics.

Delays, too, another characteristic feature, can be depicted in this kind of diagram - here by the double orthogonal bars on some of the arrows. For example, the time needed until an investment in super- or infrastructure (hotels, spas) is reflected in the quality of the assets.

Subsequently, manifold aspects had to be analyzed using hard, quantitative data, and also in part hardly palpable qualitative data. For example, in the outer loop, in the economic dimension, income and purchasing power, the evolution of the monetary value of the supra- and infrastructure, as

Concerning the layout of the High Capacity Railway, the picture was complex. In total 25 design variants were identified. The eight most plausible ones were examined more closely.

Two ideal-types (the concept stems from the sociologist Max Weber) were chosen as reference *routes:*

Variant A: by and large open-track, via a short tunnel in the region of Bad Hofgastein, and then incomplete coverage in Bad Gastein. This was the track as established, at the time, by the Austrian Railway Law.

Variant B: by and large closed-track, via a long tunnel in Bad Hofgastein, with a complete tunnel in the area of Bad Gastein and a subterranean cavern station.

The yearly costs and benefits for the reference variants were calculated in a detailed mode. The value of the investment in the railway had to be considered. Changes in tourist-generated income, regional income, tax yield etc. were calculated, and changes in wages, jobs, investments, noise and value of the tourist infra- and superstructure had to be determined as well.

The consequences of noise were calculated with a hedonic pricing function, the changes of aggregate income with the help of a tourism multiplier, etc.

All of this was compiled in a spreadsheet, and the first largely static model calculations were carried out.

What did the assessment of the two reference variants tell us?

Variant A would have disastrous consequences for each one of the components of the original offer as it also would for their totality. It would be a "devastating plan, ruinous for the whole valley" (König 2000), where the loss of the status as a health spa would only be one partial effect. The fateful process would start with an almost immediate loss of - modestly calculated - at least 15% (i.e. 300'000) of the guest nights, essentially due to the additional noise. And it would have strong and undesirable side-effects.

Variant B was in sum the one with the relatively least negative consequences. Some advantages, compared with the status quo, concerning noise and landscape in the area of Bad Gastein and Bad Hofgastein would still be compensated by two disadvantages: The increased traffic volume would affect Dorfgastein where no tunnel would be provided.

Furthermore, during the period of construction, unrest, noise and complications were anticipated.

We then proceeded with simulations using a quantitative System-Dynamics model. System Dynamics is a discipline of modeling, simulation and steering. It stems from Prof. Jay Forrester at the Massachusetts Institute of Technology (MIT). The surface of the model is shown in Figure 3. I will refrain from detailing the underlying differential equations and values. The causal loop diagram shown earlier is the basis of this model.

Forrester's genial idea was that any complex dynamic system can be modeled with two and only two kinds of variables: Stocks and Flows. In the diagram, the boxes represent stocks, e.g., the level of guest nights, and the valves represent flows, e.g., changes in guest nights. The rest are auxiliary variables. The arrows represent causal influences, the loops feedbacks. Feedback is the core building block of cybernetics.

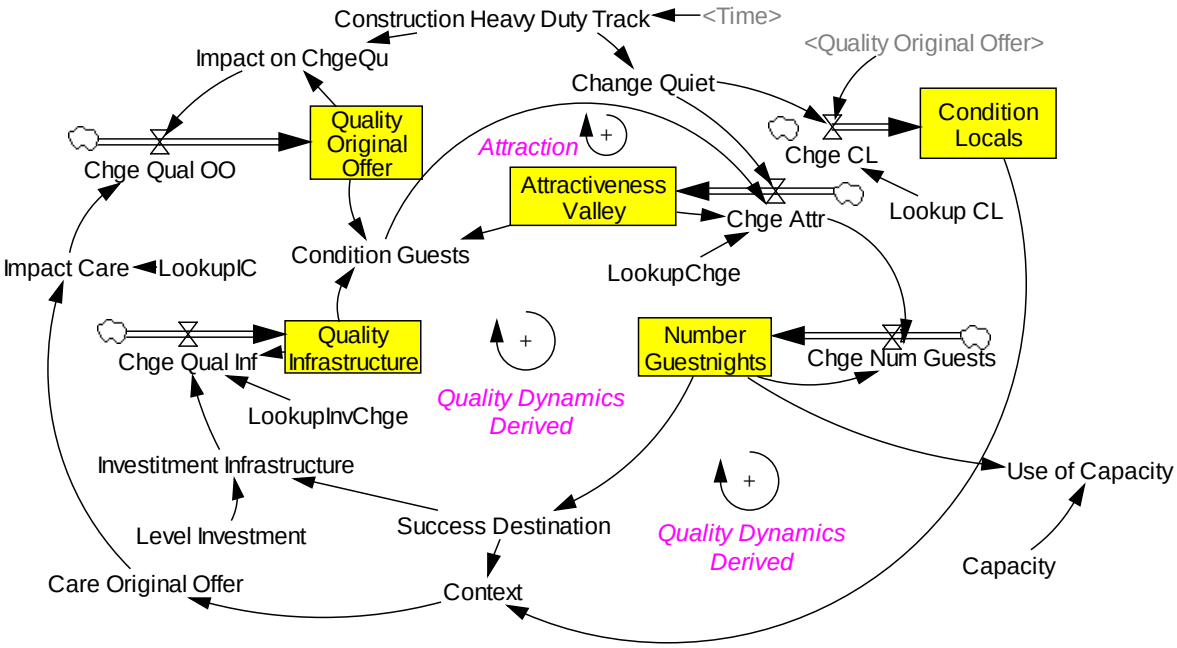

Figure 3: System Dynamics model (Stock-and-Flow Diagram)

This model generated a result which the economic analysis had not been able to deliver, namely an overall account of the dynamic evolution of the valley's economy in the years to come.

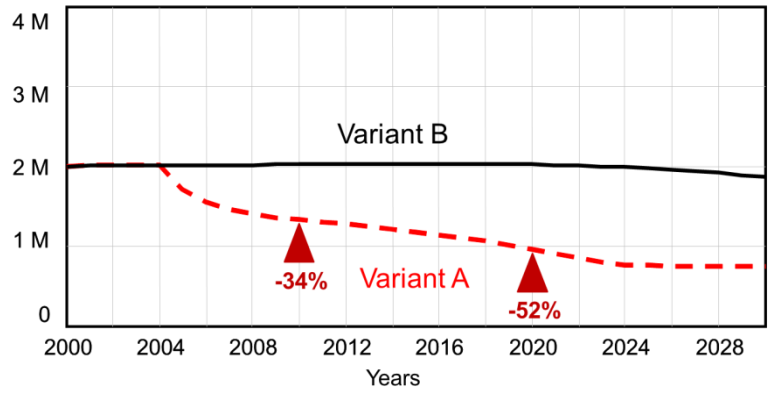

Figure 4: Evolution of guest-nights over 30 years

The economic spreadsheet model had resulted for Variant A, in a reduction of 15% of the guest nights for the initial three years. The lesson from the simulations was that the results would be significantly worse (Figure 4): For Variant A, the System-Dynamics Model anticipated a reduction of the guest nights from an initial value of two million by 34% within the first decade and a further collapse to a 52% reduction by the end of the second decade. The scenario for Variant B showed hardly any changes: The volume of overnight stays remains constant.

Hence the most environment-friendly variant was not only superior to all the others in ecological terms, but also, and to the same extent, in economic and social terms.

The realization of that optimal variant, however, would require a substantial investment. Even so, in the conventional calculation (spreadsheet model), the payback time would amount to between 0.9 to 1.6 years. Hence, Variant B was expensive, but none the less a very attractive business proposal to the Austrian Republic.

According to the dynamic scenario (System-Dynamics model), the probable payback period would be even lower, under one year, given the feedback loops in the model: It was significantly under one year. Although this value is surprising, it is not a fiction. It is simply counterintuitive. The benefit here comes from the avoidance of damage. The dynamic view had disclosed even stronger economic kickbacks than the static one did.

This spectacular result does not indicate that the intrusion was a desirable intervention, even in case of Variant B.

Here are the results of our investigations, which were presented as a basis for the pending decision:

First and foremost, our study showed that the planned intervention was a counter-systemic interference, whichever variant would be chosen.

Secondly, our report culminated in the following recommendation :

"The minimum of immissions achievable with the most gentle variant is equal to the maximum of what is still tolerable."

The most intriguing observation that we made during the entire process concerns the fact that our report had an integrative impact on the mediation forum. At the end of the process there was a strong consensus, with no significant opposition. This was astonishing; it is not every day that the opponents vote pro.

In 2002 the mediation forum approved the variant recommended by us. Thereupon the contract was submitted to the federal authority – the Austrian Ministry of Transportation, Innovation and Technology. That Ministry integrated the decision into the General Traffic Plan ("Generalverkehrsplan") of the Republic of Austria. In other words, our recommendation obtained legal status.

The plan was to be implemented by the Austrian Railways, while the Austrian State would provide the necessary financial resources. In this way a crucial decision for the viability of the Gastein Valley had been taken. The long-term perspective had won.

As mentioned, this remains an ongoing case: The implementation of the plan will not happen before 2018 / 2020.

3. Reflection

Now the question is: Why has this project worked?

The mediation forum became a platform for the reorganization of the Valley and therewith a catalyst for change. We came to see in hindsight just why the process had taken the course that it did. To that end, we reverted to the Viable System Model (VSM) of Stafford Beer, which is a main tenet of Organizational Cybernetics.

The reason for using this model is that it raises the highest theoretical claim I have found among the various organization theories. The model specifies not only the necessary but the sufficient preconditions for the viability of organizations of any kind. In other words: If an organization fulfills the criteria of the model, it must be viable. Now, which are these criteria?

At this point I shall confront you with a model that is likely to strike you as being unusual. It is of neurophysiological origin. The VSM centers on the human central nervous system (Figure 5).

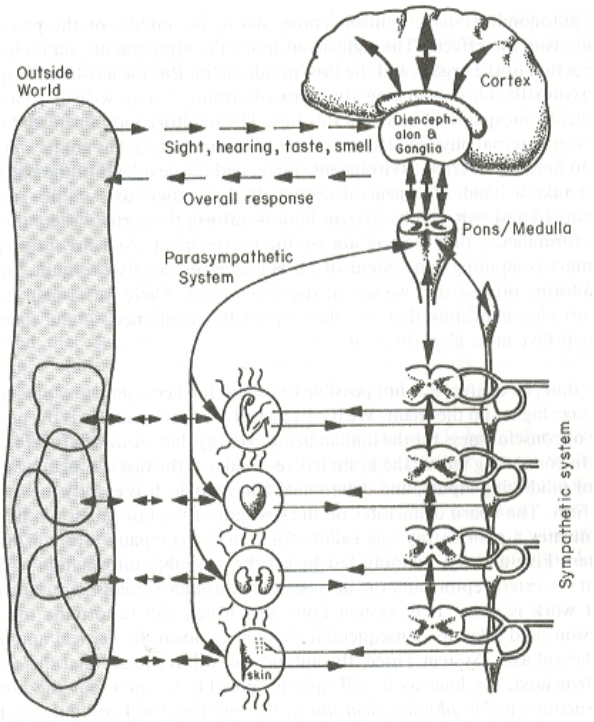

Figure 5: The Human nervous System – Neurophysiological Basis of the Viable System Model. Source: Beer 1981: 131

Humans are indeed the best exemplar for viability. Beer discovered an isomorphism, - a structural invariance between organismic and social systems. The high effectiveness of the model for diagnostic purposes hinges on that invariance. He formulated his theory as follows:

An organization is viable if and only if it features a specific set of components and relationships, that will be outlined here (Figure 6):

We start with the basic units (represented by the red circles), e.g., the divisions of a company in their respective environments. The management functions specified by the theory are as follows (Beer 1981, 1985):

- The management of the basic units (Component 1)
- The operative management of the company as a whole, - the short- and medium-term direction (Component 3)
- The coordination between the basic units (Component 2), and an audit channel (Component 3*)
- Strategic management or Development function, - the long-term orientation (Component 4)
- Normative management or ethos of the whole system, - the almost timeless principles and values (Component 5)

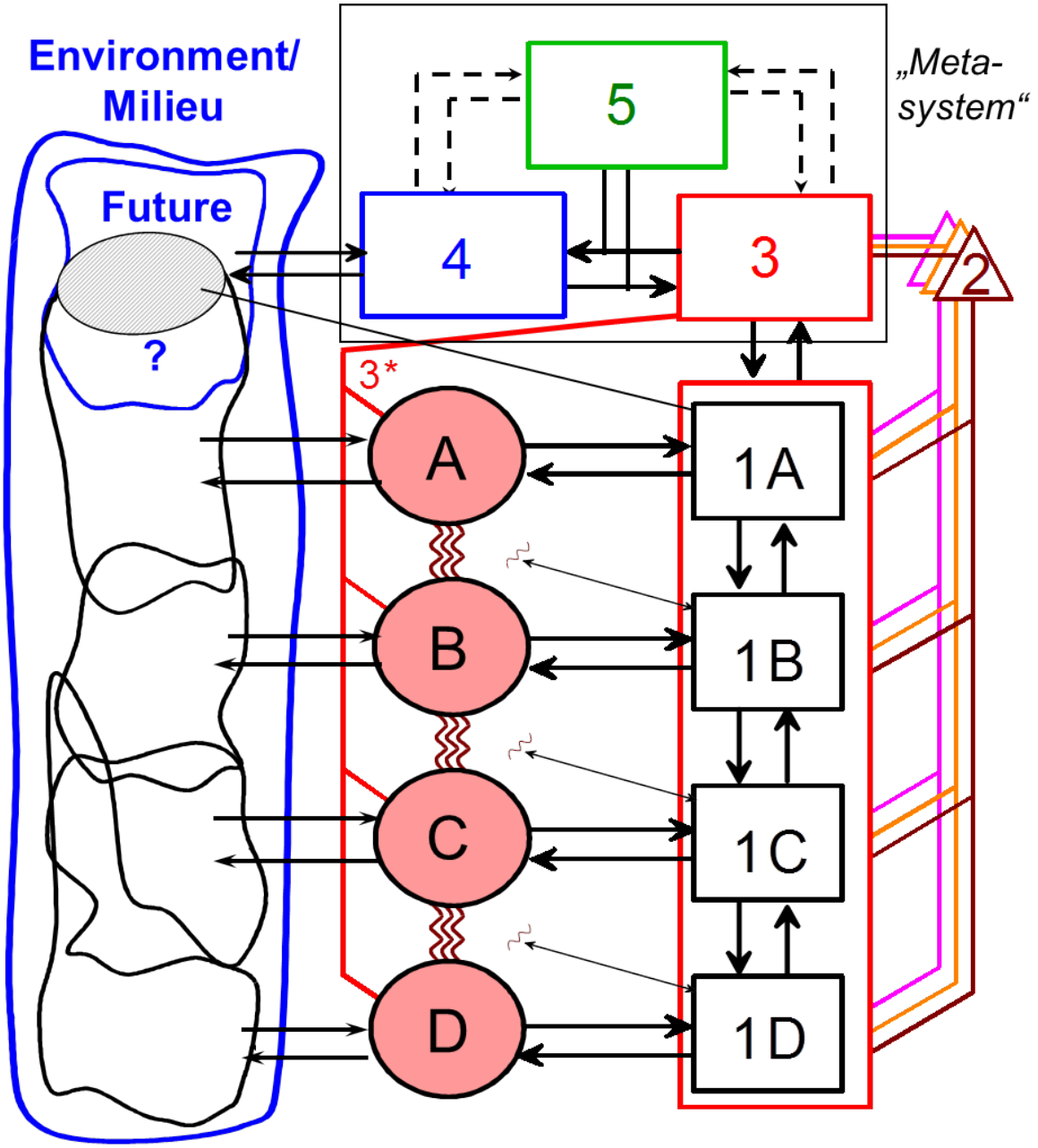

Figure 6: The Viable System Model (After Beer 1981).

Deficits in this structure result in an impairment of the viability of the respective organization.

The model is most suitable for making diagnoses, but is also used successfully for the purpose of design.

What did the analysis with Beer's VSM model tell us about our case? It showed that a structure had evolved in the Gastein Valley that was crucial for the success of the project (Figure 7):

- Basic Units: the three municipalities of the Valley, in their environments.

- Component 1: Management of basic units: The community council in each village, presided over by the mayor.
- Component 3: Operative management at the level of the valley as a whole: A core team around the three mayors. In this way, not only the concerns of the single municipalities are met, but also the overarching common interest is pursued in its own right.
- Component 2: The coordination mechanisms consists of information platforms and task-oriented teams (e.g. for marketing, infrastructure etc.)
- Component 3*: The direct access of general management to the basic units is ensured by citizens‘ fora and the „management by walking around“.
- Component 4: The long-term strategic development is essentially embodied in the mediation forum with the associated external partners. Last but not least, the systems analysis and design became an enduring process, i.e. more than a consulting report. The view on the future and the overall environment, in addition to the partial environments of the municipalities, is crucial.
- Component 5: the normative management or normative governance: It is manifest in a canon of values, an ethos to which the Gasteiners are committed. This core identity of the social system is explicitly represented by opinion leaders and continually debated in the socio-political network.

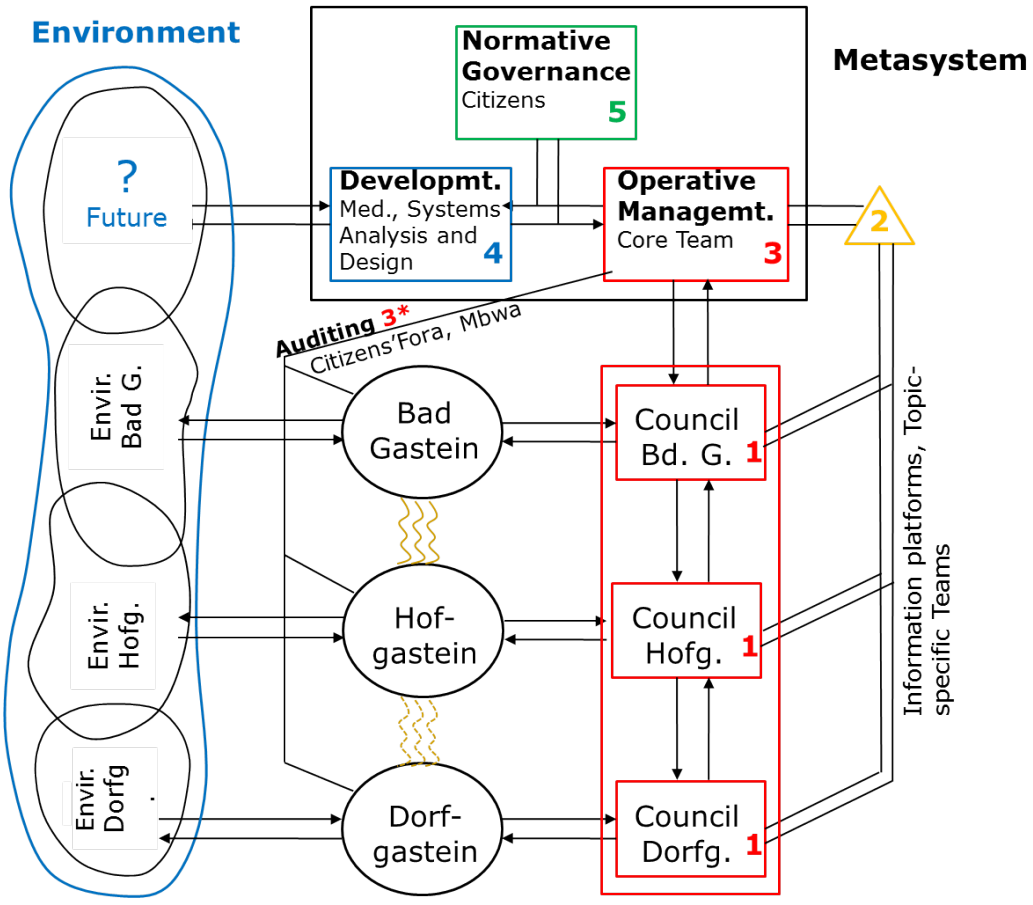

Figure 7: Structural View on the organization of the Gastein Valley

So much about the structure: It indicates a high level of viability in the Gastein Valley. We have now identified its organization by means of an “X-Ray”. That structure generated

powerful processes of self-organization and self-reference, - i.e. the internal reflexion of ongoing matters. Those processes led to the construction of a new reality of the social system.

What has cybernetics yielded here? In the case under study, a transdisciplinary synthesis of partial perspectives occurred.

Not only economic aspects were considered in the study; the ecological and social dimensions were equally included. Given the complexity of the subject matter, a mono-disciplinary approach would not have enabled a sound synthesis of this kind. The issue here was not solely the profit of the economy but the welfare of the whole, - the sustainability of a valley.

So much, then, for this case from the standpoint of applied research. The research object was a region. The research design was built on a case study and a simulation, in which theorems as well as models and methods were applied (Figure 8).

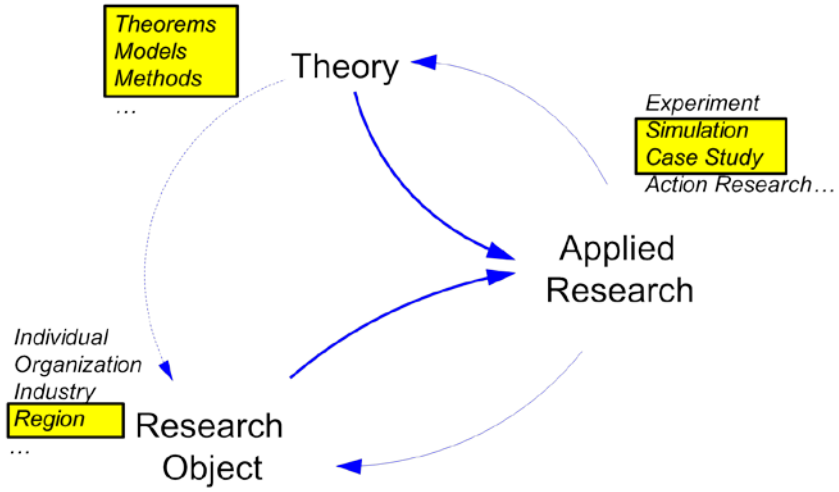

Figure 8: Applied Research – Classification of the Case Study

This combination of research object and methodology raises my final question: Where is the advancement of scientific knowledge in this case? Or was it merely a consulting project like many others?

Not the latter, for our case rendered a remarkable theoretical-conceptual “harvest”. The theoretical contribution lies in the fact that the methodology of systems analysis was advanced with a multi-method concept. The NEW factor in this combination is its particular achievement of a synthesis of system dynamics with organizational cybernetics. Without that synthesis one would have known that the project was a success, but no why.

4. Methodological and Epistemological Considerations

Applications such as the one studied up to this point, in combination with theoretical considerations, have led to a pair of conceptual “tools” - a methodological heuristic termed the *Integrative Systems Methodology*, and an epistemological frame called the *Complementarities Framework*.

4.1 Towards an Integrative Systems Methodology

When dealing with complex phenomena, the procedure usually follows the steps such as (Figure 9): Model – Assess (Diagnosis) – Design (strategies, structures, etc.) – Change (of the system). The point of origin generates goals with respect to a conceptual frame.

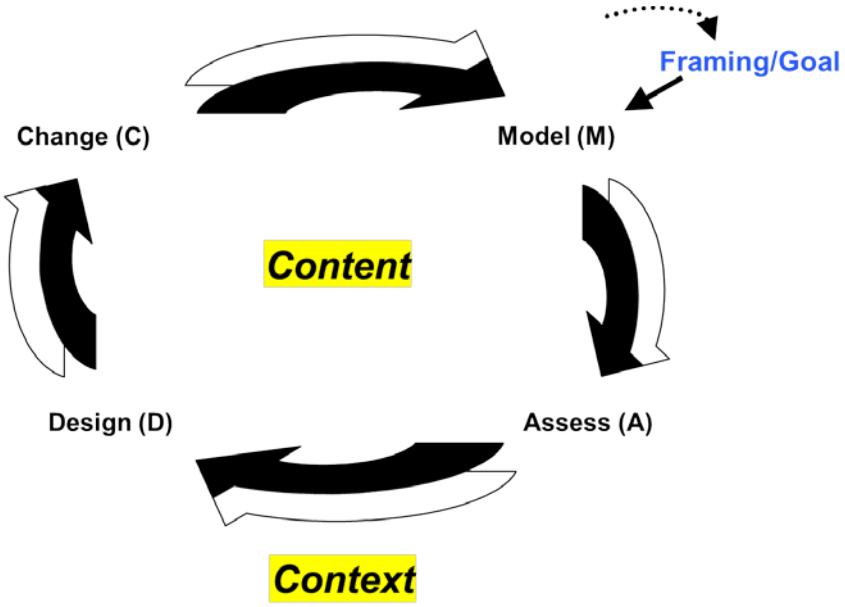

Figure 9: Integrative Systems Methodology – Overview

From projects like this one, an important insight has emerged: In rather complex cases, the problem solution must take into account not only the *content* aspect, but also the organizational *context*. Therefore the arrows in Figure 9 are two-colored.

The converse thus holds: If one works only on the content, the problem solution will probably be realized defectively. Therefore, the multi-method conception is what probably made the difference, transcending a mere report to frame a successful project in the political space. It was not enough to provide well-founded decision-support: The sufficient precondition for success was the evolution of a structure that enabled the sustainable viability of the valley.

To add one essential aspect in a more detailed schema (Figure 10), which holds for both content and context. Instead of four steps we see seven, inspired by a heuristic from Gomez and Probst (1987).

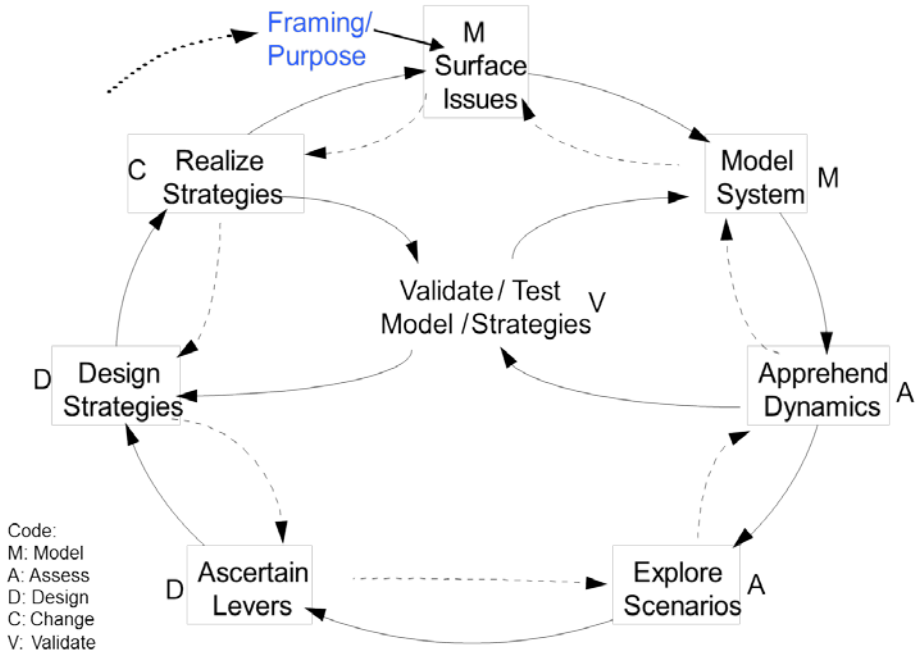

Figure 10: Integrative Systems Methodology – Heuristic for dealing with content and context

What is new about this diagram? The central point is validation: This concerns the question about whether models and strategies are valid. Does the model accurately represent the reality under study? Is the strategy appropriate to reach the goals, etc.? These questions must be examined carefully in both the qualitative and quantitative domains.

In the field of modeling and strategizing, validation is probably the greatest challenge for the years to come.

4.2 Epistemological Framework

To lift these methodological matters to the epistemological level, a complementarity-framework is shown (Figure 11): It consists of four pairs of concepts, which are normally perceived as mutually exclusive polarities.

The proponents of quantitative methods often are insufficiently aware of the relevance of qualitative approaches, and vice versa. Yet, both are necessary for coping with complex challenges. Either method must complement the other.

Also, the mutual antagonism between the objectivist and subjectivist perspectives is an artificial one. No doubt, when modeling, one must abide by the principle of objectivity. However, at the same time the involved agents need their own models in order to act sensibly. The models in our case, for example, were also the models of the mediation forum.

Instrumental rationality is of little value if it is not embedded in communications. Our models were, so to say, „well-cutting instruments“, but it was the network of communications that led to their effective use, notably in the meetings of the mediation forum. Had it been otherwise, we assessors would likely have ended up like the incompetent surgeon who simply reached for sharper knives.

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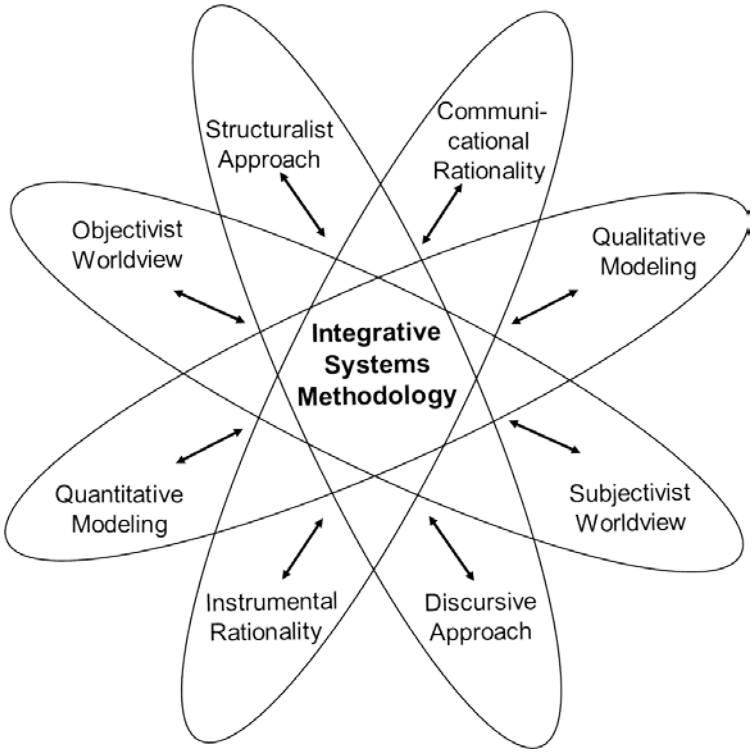

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And finally, the structuralist and the discursive approaches must be connected. The new structures under development had to stand the test in the fora of citizens, etc., in other words: They had to be validated.

The left half of the diagram conveys the positivistic position, while the right half shows the interpretative one. These two should not be treated as mutually exclusive but as completing each other: Therefore the term “complementarities framework”.

The main point here is that the polar opposites on each axis, which are normally seen as mutually exclusive, should be integrated: Not qualitative *or* quantitative modeling, but

qualitative *and* quantitative modeling, etc. This calls for a new way of thinking. The case study shows that this postulate is realistic, not just a chimera.

5. Outlook

Earlier on, Jay Forrester was mentioned, the great system theorist and father of System Dynamics. He keeps urging his alumni, of whom I am one: “Dedicate your modeling efforts to the big problems of humanity”! That directive has induced me to orientate my research and teaching activities accordingly: They are meant to make a contribution to the challenges of our time. Among those challenges are the improvement of organizations and management. Another aspect, prior to that, is the use of better mental and formal models.

Dealing with complex issues such as the one at the center our case study often calls for more sophisticated methodological arrangements than a mere reproduction of a standardized procedure. Here, a synthesis of two approaches to modeling the content and the organizational context was of key importance. The first model came from the methodology of System Dynamics, the second from Organizational Cybernetics. Also, the combination of quantitative and qualitative models and methods is often needed. So in our case, where the systems analysis was carried out, steps were taken first with a causal loop diagram, and then with a simulation model.

The Systems Approach adopted here is based on a broad view. In this vein, a particular concern of the Integrative Systems Methodology outlined is to overcome slavish short-termism at the expense of a long-term orientation. Bonded with this concern is the aim at taking the path of an economic evolution that is ecologically and socially sustainable.

The case described here is only one example. But hopefully it conveys an insight into the great possibilities of designing a desirable future, if concepts and methods rooted in the systems approach are applied in a fruitful way.

The potential of cybernetics and systems is enormous. To date, however, it has been explored only to a small degree. And so I am indeed fortunate in having been able to introduce several generations of young scientists and practitioners to this matter. They have gotten hold of a new outlook on the world. My conviction is that they will move much, wherever they are and whatever they succeed in doing. They will navigate through the seas of complexity and build bridges into the future.

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