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Complex Decision Making

Theory and Practice

With 132 Figures and 22 Tables

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Chapter 11

Saving a Valley: Systemic Decision-making Based on Qualitative and Quantitative System Dynamics

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1. Introduction

The purpose of this contribution is to give substance to the notion of "systemic decision", on the basis of a pertinent case study. This case is about a weighty decision on an issue of exceedingly high complexity. The paper traces how qualitative and quantitative evaluations were combined within a systemic framework, to arrive at a decision whose superior quality could not have been attained if a non-systemic approach had been used.

According to scientific standards, decision makers are supposed to assume a rational posture when confronted with complex, dynamic situations. They should test their assumptions and corroborate their resolutions with sound arguments, basing them, if possible, on quantitative reasoning [see for example: Black 1999].

In practice, however, far-reaching decisions are often taken by relying on hunches. This approach is neglectful, however, of the nature of complex systems. These systems often exhibit behaviors which totally refute the presumption of the decision-makers. Particularly for those who rely merely on their own hunches, such results are counterintuitive [Forrester 1971]. They are usually brought about by unknown couplings of critical variables or unintended side-effects, i.e., consequences that were not anticipated.

On the side of theory, however, management science provides devices for dealing with complex issues. It has not only developed algorithms for quantitatively orientated decision-making. It has also come up with many qualitative heuristics to cope with complex issues wherever quantification is impossible or contraindicated. Essentially, those who advocate either one of these approaches have by and large remained

separate, bivouacked in two "camps". Consequently, there have not been many pleas for combining quantitative and qualitative methods or methodologies. However, the growing pressure for coping with complexity appears to be leading to a better understanding of the need for integrating the two domains, and of how to bring about such integration[1]. But dealing with high complexity needs something more than a combination of methods or methodologies. It requires a different conceptual framework. I am referring to a systemic approach, or more exactly to an underlying framework based on systemic thinking.

Systemic thinking deals with systems, i.e., organized wholes made up of elements and relationships.[2] Complexity is a function of the uncertainty faced, the dynamics of the relationships, but also of the quantity and variety of the elements of the system-in-focus [cf. Rescher 1998]. The dynamic complexity of a system may give rise to new properties of that system, a phenomenon called emergence. In a nutshell, systemic thinking is holistic-integrative and multidimensional, while also being dynamic, analytic and synthetic.

In the following case it will be shown how a complex decision situation was supported by a system study which powerfully influenced the decision for the better in the social system affected. From a methodological point of view the study was remarkable in that a synthesis of qualitative and quantitative methods occurred, grounded in a systemic framework and customized to the issues at hand. It even occurred smoothly and to good effect. This was achieved on the basis of an innovative conceptual orientation, which provided to decision-makers a stronger lever than others for coping with the complexity faced when confronted with the difficult situation that will be described in the next section.

The case study will begin with a description of the context, i.e. the initial situation. Thereafter, the conceptual approach taken will be outlined. Then the steps of the decision process will follow, with decision analysis and synthesis. This will culminate in an account of the final decision. A reflective summary and outlook will conclude the paper.

2. Context

The Gastein Valley (Gasteinertal) in the county of Salzburg is 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).

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 also a mandatory project, directly derived from the membership contracts of Austria with the European Union.

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[1] Examples of approaches for integrating different methodologies are, e.g., Zeisel 1984, Mingers & Gill 1997, Rosenhead & Mingers 2001, Schwaninger 2004.

[2] The concept of *system* is a very general one, and it is subject to different interpretations.

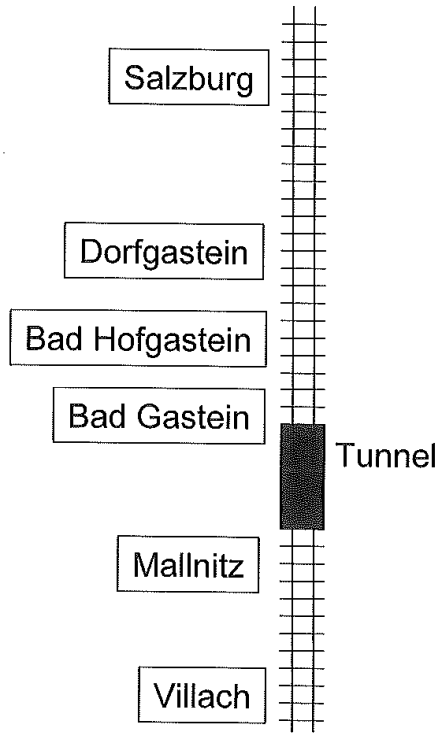

Figure 1. Scheme of the train connections to and from the Gastein Valley

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 incisive 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 growth of 662 percent [Schwanhäusser 2000].

In the whole county of Salzburg and especially in the Gastein Valley, tourism is a very important economic factor [Scherrer 1998]. More than 30% of the work force of the Valley is employed by the hospitality industry. 60% of all jobs in the area depend directly or indirectly on tourism. This comes close to constituting an economic monoculture.

The tourist assets include:

- An outstanding ensemble of highly attractive natural factors (alpine landscape, flora, fauna etc.).
- Beautiful, originally preserved villages enriched by natural and cultural monuments.
- Health resorts based on a famous and powerful cure (thermal springs containing Radon and a healing gallery with the largest natural inhalatorium in the world)[3].

[3] The Gastein Valley is famous for the treatment of: Inflammatory rheumatic disorders, degenerative and deforming joint disorders, neuralgia, chronic pain, disorders resulting from sport and accident injuries and respiratory disorders. In addition, fertility and virility disorders, geriatric syndromes, skin diseases and disorders of the immune system and allergies are objects of the radon-based therapies.

- An advanced tourist superstructure in both qualitative and quantitative terms (9100 - mostly premium - beds in hotels and 7700 beds in other facilities).
- A comprehensive tourist infrastructure (healing gallery, thermal spa, cure and rehabilitation centre, sport medical centre, thermal mineral springs, convention centre).
- An exceptionally spacious network of promenades and hiking trails.
- 200 kilometres of ski-runs rated at all degrees of difficulty, about 60 kilometres of cross-country skiing tracks, 10 funiculars and 36 lifts.
- A set of marked socio-cultural characteristics, including a strong tradition of hospitality and ethnic customs.

Based on this combination of attributes and assets, the Gastein Valley is highly attractive, in particular for health-oriented types of tourism. Many of these market segments, such as health vacation, fitness vacation, rehabilitation and cures, are growing in the target markets, particularly in Germany.

In sum, the following critical success factors for the Gastein Valley destination were identified [Schwaninger/Lässer 2000]:

- Nature
- Health resorts (thermal springs)
- Quietness / absence of noise
- Beauty of landscape and settlements
- Tourist infra- and superstructure
- Socio-cultural factors, hospitality in particular

It is chiefly the features of peaceful quiet and health resorts which establish the basis for awarding official health-spa status to both communities, Bad Gastein and Bad Hofgastein.

3. The Need for a Solution

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.

It was clearly discernable that major changes in two dimensions would occur:

- Infrastructure (separation effects stemming from the new track and the optical and therewith esthetical changes in the landscape).
- Immissions, namely noise and - to a limited extent - vibrations.

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 tracklayout arrangement. On the other hand, a group around 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, namely

- Austrian Railways (ÖBB)
- Ministry of Transportation, Innovation and Technology
- County of Salzburg
- Environmental attorneyship
- Austrian Chamber of Commerce, tourism section
- Municipality of Bad Gastein
- Municipality of Bad Hofgastein
- Tourism Association Bad Gastein
- Tourism Association Bad Hofgastein
- Civil initiative "Lebenswertes Bad Gastein"
- Civil initiative "Lebenswertes Gasteinertal - Bad Hofgastein"
- Austrian Alpine Association - Section Bad Gastein
- Civil Engineers Spirk & Partner
- Attorney Dr. H. Vana as representative of the municipalities and civil initiatives

The forum decided to schedule regular sessions and to form task forces around core issues: Tracking variants for Bad Gastein, tracking variants for Bad Hofgastein, criteria for comparing the variants, noise, etc.

The leaders of the mediation forum asked me to develop a decision base which they called "economic assessment", to serve as a foundation for the decision process. 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 specialists 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. The question, therefore, was which one of the possible variants considered for that intervention was to be realized. This study would have to help the forum in taking its final decision.

4. The Conceptual Approach

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 the variables of the multiple dimensions considered.
- It had to be dynamic, i.e. a static "photograph" of the situation after the intervention, 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.

As a consequence, this would be a study of substantial complexity. The approach promised, however, to lead to a broader view and to deeper insights as a basis for decision-making.

We started with an investigation on the spot. This included visits of Bad Gastein, Bad Hofgastein, the main infrastructural components, hotels, restaurants, natural and cultural monuments, etc. We also had meetings and led interviews with exponents of the two constituencies. Finally, we gathered written documents and set up information channels. Several local persons were designated to provide us with any further documents or data needed.

Back at our university, we conceptualized what we had learned. In the first place, we drew a conceptual and highly abstract map of the issue under study (Figure 2)

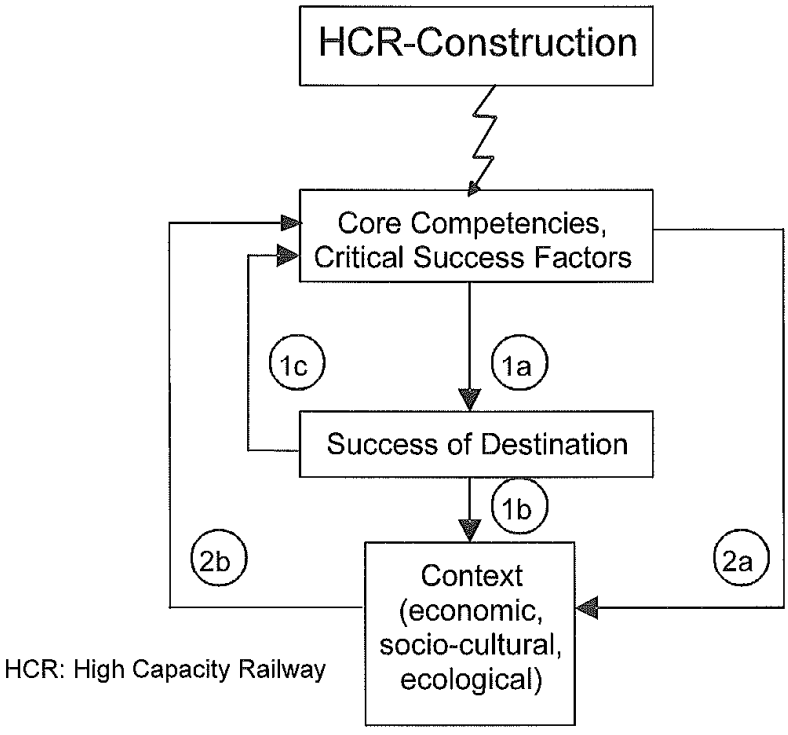

Figure 2. Object of study - conceptual map

This was also the road map for our ensuing investigation.

The construction of the High Capacity Railway (HCR) was conceived as an initial "shock" which impinged on the core competencies and the critical success factors of the Gastein Valley. From there, two causal chains were identified which were rightly to become the object of detailed studies:

1. Would the construction of the HCR have effects on the core competencies and critical success factors of the Gastein Valley destination (1a) and successively on the economic, socio-cultural and economic context (1b)? If yes, which would be the consequences and what would be their proportions? Ensuing feedbacks from core competencies and critical success factors (1c) were to be taken into account.
2. Would the consequences of the HCR construction on core competencies and critical success factors entail implications for the context (2a), and if so which ones? Also here, eventual feedbacks from the context to core competencies and critical success factors (2b) were to be analyzed.

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

This analysis allowed us to operationalize and specify the programmatic scheme (Figure 2) with a view to framing the further steps of the study. Instead of the all-inclusive concepts of core competencies and critical success factors, we were now in a position to revert to more concrete terms related to the natural ("original") and derived assets (Figure 3).

The representation used here is a common feature of qualitative System Dynamics[4]. 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, or the causal connections leading from a variable back into itself. Also delays, another characteristic feature, can be depicted in this kind of diagram.

In the present case, we can identify two self-reinforcing "Attractiveness Loops" [cf. Vester/vonHesler 1988] with further ramifications[5].

The first and 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

[4] System Dynamics is a widely used methodology for the modeling and simulation of complex systems, developed by Prof. Jay Forrester at MIT-Massachusetts Institute of Technology [Forrester 1961]. System Dynamics models are made up of closed feedback loops. SD is particularly apt for the discernment of a system's dynamic patterns of behavior, which may be „counterintuitive" [Forrester 1971]. It shows particular advantages for applications to social and socio-technical systems.

[5] On the methodology for elaborating these qualitative schemes, see Anderson/ Johnason 1997, Vennix 1996.

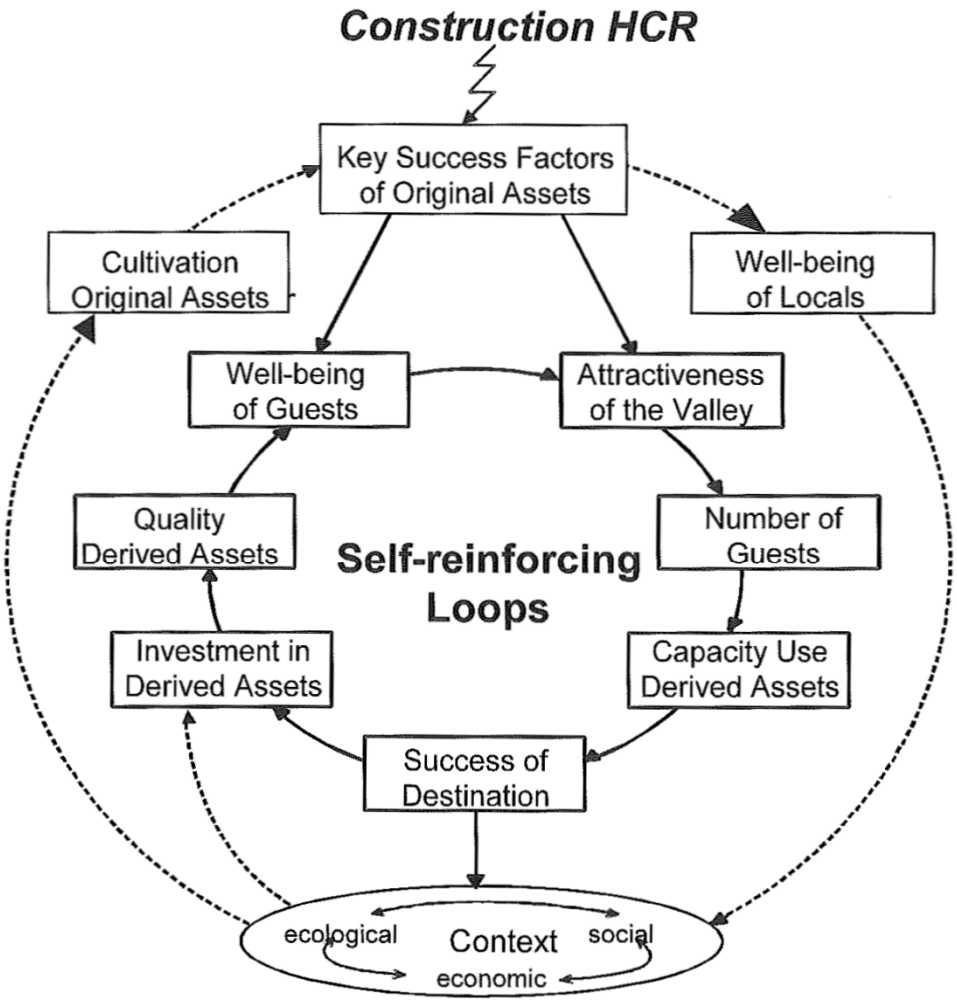

Figure 3. Causal loop diagram

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). That very quality again impinges on the well-being of guests and the attractiveness of the valley.

The other, indirect and secondary loop on the outer side of Figure 3 centres on the internal context of the Gastein Valley, a context which is economic, socio-cultural and ecological. This context on the one hand is stamped by the well-being of local inhabitants. On the other hand it is influenced by the success of the destination. Via the two variables 'cultivation of the original set-up' and 'well-being of locals', the context is coupled with the key variables of the original set-up ("original assets")[6].

[6] Under 'original assets' we subsume mainly the natural conditions, e.g., locality, climate, landscape, flora, fauna, the aesthetics of the man-made environment, and the socio-cultural atmosphere, e.g., hospitality, tradition, customs. Under 'derived assets' we subsume the tourist infrastructure (e.g., health centers, funiculars, tourist offices, etc.) and the tourist superstructure (hotels, restaurants, etc.). For details, see Kaspar 1996.

Both loops are closed and self-reinforcing, being influenced by only one exogenous variable of interest - the construction of the HCR.

The sequence ran by and large from synthesis to analysis to synthesis. First we looked at the larger system of which the HCR is part, i.e., the Gastein Valley as a whole and its properties. Then we went about accounting for the behavior of that larger system as a function of the impacts of the HCR in different dimensions. Finally, we put these partial aspects together to explain the role of the HCR within its containing whole [cf. Ackoff 1999].

5. Decision Analysis

The study proceeded to an extensive analysis along the lines traced by the conceptual schemes (Figures 2 and 3). Accordingly, the analysis was made up of three blocks, namely:

1. Effects of the construction of the HCR on key variables of the original assets.
2. The primary causal loop.
3. The secondary causal loop.

In each one of these blocks, the pertinent variables were examined one by one. This refers to all the variables as listed in the causal loop diagram. In some instances the analysis even went down to a more detailed level; for example, in the case of the key variables (block 1) certain theoretical foundations were given, then the analysis examined quietude/noise, nature, beauty of villages and landscape, health resources/recreation factors, socio-cultural factors and hospitality in particular.

In the case of the inner, primary loop (block 2) the objects of analysis were the number of guests and capacity utilization, success of destination, investment in infra- and superstructure, quality of infra- and superstructure and well-being of guests.

The variables analyzed in relation to the secondary loop (block 3) were the well-being of locals, the economic context, the social context and the ecological context. In the case of the economic dimension, a number of partial aspects were examined, i.e., income and purchasing power, evolution of value in the hospitality industry, evolution of value in the other components of the derived tourist offer and intangible effects.

As far as these variants of the layout of the HCR are concerned, the picture was complex. For the Bad Gastein area alone, five variants of the track layout were established, and for Bad Hofgastein there were five additional ones. As the former ones could theoretically be combined with the latter ones in any way, the theoretical number of possible variants amounted to 25. Of these, the eight most plausible ones were examined in detail.

In the first place, the analysis referred to two ideal-types, namely:

Variant A: by and large open track, via a short tunnel in the region of Bad Hofgastein (Variant 1) and incomplete coverage in Bad Gastein (Variant 8). This was the track as established by the Austrian Railway Law.

Variant B: by and large closed track, via a long tunnel in Bad Hofgastein (Variant 3), a complete tunnel in the area of Bad Gastein and a cavern station (Variant 2).

These were the reference variants for the analysis[7].

For each one of the variables or partial aspects thereof, the analysis detailed first the basis for the assessment, and then proceeded to an evaluation of the consequences. In each case that evaluation was specified for the two reference variants of the HCR construction.

In the case of the variable "health resources/recreation factors" - for example, the indications treated in Bad Gastein (cf. footnote 3) - the weight of the natural factors and the impact of noise (permanent and peak noise levels) were ascertained in the section 'basis for the assessment'. In the section 'evaluation of the consequences', disturbances and effects on health and rehabilitation processes, as well as detriments to aesthetic qualities, were identified. For Variant A the transgression of noise standards as prescribed for the health-spa-status would happen; this would lead to attrition of that status. For Variant B a slight improvement of the basis for recreation and rehabilitation was foreseeable (except for the period in which the construction would be carried out).

The analysis was orientated by the conceptual schemes drafted at the outset. The logic of the analysis was essentially that of the sensitivity-analysis type. The pertinent question was: "How will the dependent variables react to different changes of the independent variables?" Much of this had to be answered in qualitative terms. These results were made readable due to the highly structured nature of the report.

On the other hand, much of the analysis was conducted along quantitative lines. 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, changes in wages, jobs, investments and value of the tourist infra- and superstructure had to be determined as well. This made extensive data collections and also a detailed modeling necessary.

It lies beyond the scope of this paper to reproduce all the functions of that model here. However, three examples should give an idea of how qualitative constructs were translated into meaningful quantitative indices:

1. In the section about noise and its consequences, we referred to a hedonic pricing model by Pommerehne [1988], which allows one to deduce changes in the value of properties (via changes in rents) as a function of noise levels. The formula is:

$$\text{Ln } M = -0.002943 * dB^{1.3},$$

where M is the level of rents in Swiss Francs and dB the noise level in decibels.

[7] The variants were defined as a function of the installation of tunnels and their different lengths as well as other features of construction. E.g., Variant 8: New track parallel to the extant one (Bad Gastein; Variant 2: Continuous tunnel between Bellevue and Böckstein, and cavern station (Gastein); Variant 3a: short tunnel after Steinbach Station.

2. The construct "Success of the Destination" (primary loop) was operationalized by means of two indicators, the change in income from tourism and the value-added generated by the hospitality industry. The formulas were:

(2.1) $\Delta TGE = \Delta L * 1000$,

where TGE is the total income of the valley from tourism, L the number of overnight stays of tourists and 1000 an empirical value of the daily expenses of tourists (in Austrian Schillings).

(2.2) $\Delta WS = \Delta TGE * 0.62 * (BE - WA - ABS)$,

where WS stands for value-added, BE for the income of the local hospitality industry as 100%. WA and ABS are the respective percentages to be deduced for the cost of merchandise and depreciation. 0.62 is the hospitality industry's fraction of the income from tourism.

3. Under economic context (secondary loop), the macroeconomic income generated was calculated as follows:

$\Delta Y = \Delta TGE * \mu$,

where Y is the macroeconomic income generated by tourism and μ the multiplier [calculated with 1.37, a value ascertained empirically: Häusel 1985].

In a final section the results of the analysis were broken down to the level of the further variants, by means of a rough quantification. The comparison of the qualities of the different options came down to a set of scores on a scale between 0 (for Variant 8) and 1 (for Variant 2)[8].

6. Synthesis and Decision

The synthesis was carried out at two levels, the level of the three blocks of the analysis and the level of the total of analyses. The synthetic judgments were again underpinned by both qualitative and quantitative methods.

Firstly, at the end of each block of analysis a synthesis was undertaken which showed the larger picture, for example in case of the first block the overall change in attractiveness of the valley. 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

[8] For example, the Variant 3a mentioned earlier got a score of 0.5.

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

Similar syntheses were carried out concerning the primary and the secondary loops. Both were identified as vicious loops, and in the case of Variant B the "vice" was even found to be disastrous.

The synthesis at the level of the whole had to bring the partial aspects together in clear-cut and easily comprehensible categories. The qualitative approach consisted in putting together all the partial, descriptive results of the analysis in a synoptic manner and lodging them in a special chapter. The quantitative approach resulted in a synthesis of economic results in another special chapter as well.

In addition, a small, highly aggregated, quantitative system dynamics model[9] was built on the basis of the conceptual scheme in Figure 3. This model[10] 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. The most expressive result of the respective simulations is shown in Figure 4.

The main lesson delivered by this curve is that the results would be significantly worse than the ones calculated by the economic analysis: That scenario was calculated on the basis of a 15% reduction in guest nights (from two million to 1.7 million) within the first three years, at the outset for the case of Variant A. This was still in accord with the results of the economic calculus. The SD model, however, showed a decline of guest nights, from the initial value of 2 Million, by 34% within the first decade and a further reduction up to 52% by the end of the second decade (see Figure 4).

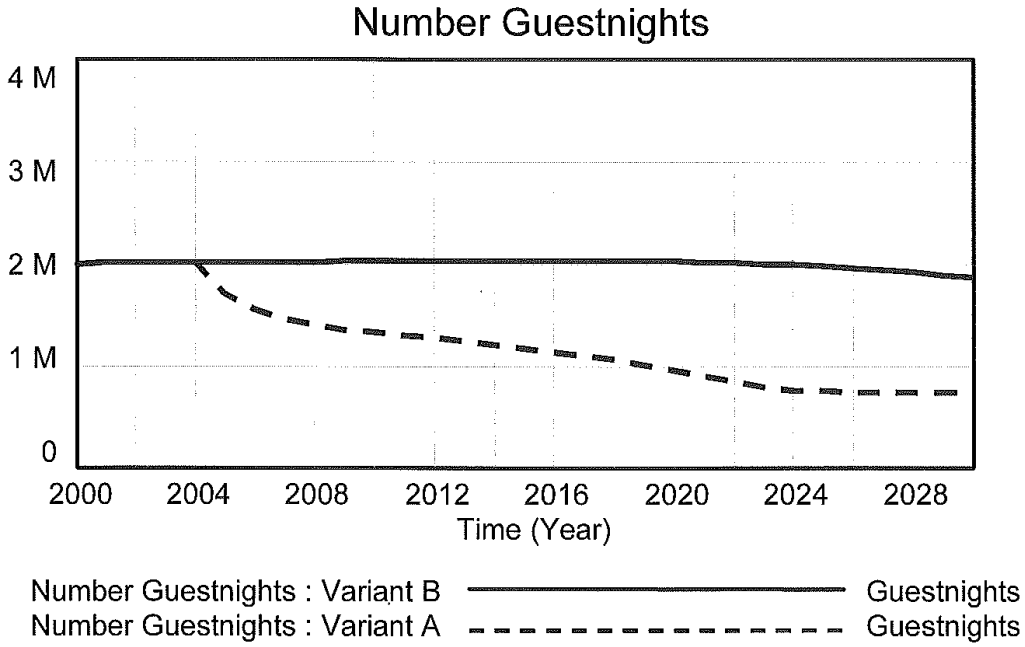

Figure 4. Evolution of the number of guestnights over 30 years (Scenario for Variants A and B)

[9] System Dynamics simulation is of the continuous type; the mathematics is based on differential equations [cf. Sterman 2000].

[10] The model is not reproduced here, but is scheduled for separate publication.

Finally, 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 intervention was a counter-systemic interference, whichever variant would be chosen.

Secondly, our report culminated in the following recommendation[11]:

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

In other words, the study had led to the conclusion that out of the many options for the HCR layout studied the most environment-friendly variant (Variant B) was superior to all the others not only in ecological terms but also, and to a comparable degree, in macroeconomic and social terms.

The study had found, among others, the following concrete result: The optimal variant (Variant B) required an additional investment for its realization. According to the calculations that were carried out, the period needed for the amortization of the pertinent amount was found to be no more than 0.9 to 1.6 years[12]. It became clear that the most expensive variant was indeed a very good business proposition for the Austrian Republic.

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. We presented our results to the forum's plenary sessions twice. The first instance was in the middle of the study period, when the overall direction was clear but only a few of the details were apparent, and the second one, when the report had been finished. During the time we worked for the forum, we observed a successive convergence of the opinions among the participants. At the end of the process there was a strong consensus, with no significant opposition.

In 2002 the definite decision to adopt Variant B was taken by the forum. The pertinent project was then integrated into the General Traffic Plan ("Generalverkehrsplan") of the Austrian Ministry of Transportation, Innovation and Technology. The plan was to be implemented by the Austrian Railways, while the Austrian State would provide the necessary financial resources.

7. Conclusions

The case study reported on here brings several features to the fore, features which characterize a systemic approach to studying complex and dynamic issues.

The system under study exhibited exceptionally high complexity. The whole valley's socio-economic existence was challenged by the planned construction of an HCR system.

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[11] In the original: "Das mit der schonendsten Variante erzielbare Minimum an Immissionen ist gleich dem Maximum des noch Tolerierbaren" [Schwaninger/ Lässer 2000: 95].

[12] If the additional System Dynamics-based scenario (Figure 4) would hold, then the payback time for Variant B would be 4 months only [Schwaninger/ Lässer 2000: 81].

The intervention and the ramifications of its effects as studied in this project made up a multidimensional web of relationships susceptible to analysis. That web produced a dynamic pattern which only a synthetic approach could fully elicit.

This study was a systemic one, which is expressed in several features: First of all, it was multi-dimensional, holistic and integrative. This is remarkable insofar as studies of this kind tend to be limited to one dimension, whether economic, psychological or social and so forth; and they are also often static. This study was multi-dimensional in that several dimensions - in particular the economic, social and ecological dimensions - were examined. It pursued a holistic approach as it focused on the larger whole and integrated the partial aspects of the different dimensions into a larger picture.

Furthermore, the study was based on a dynamic view. The dynamic patterns elicited, e.g. the long-term evolution as drawn by the System Dynamics model, were not only a useful but also a necessary ingredient for an understanding of the situation.

Finally, this study coupled analysis and synthesis. This combination stands in contrast to the monochromatic dominance of analysis and the lack of synthesis widely observable in studies of a comparable kind. However, this combination of analytic and synthetic reasoning is a basic feature of systemic thinking, a feature which is vital to a deeper understanding of a complex issue [Ackoff 2003].

It is cogent to argue that the results of a less systemic study, i.e. one not showing such multi-dimensionality, dynamics, and synthesis, etc., could not reach the depth and richness achieved in this case for both the investigation and its conclusions. Besides the richness of the conclusions presented in the final report, one must, e.g., take into account the valuable insights conveyed by the systems diagrams, the closed loop diagram (Figure 3) in particular. This richness offers a better basis for decision-making in a complex, dynamic environment than the one-dimensionality of more reductionist studies.

Both the analytical and the synthetic components of the study made use of qualitative as well as quantitative approaches. Neither one nor the other was sufficient in itself. The combination of both proved to be necessary. The qualitative analysis was extensive, yet the partial conclusions drawn on the basis of that analysis were highly differentiated and not easy to integrate into a conclusive picture. Contrary to many other cases, however, all of them pointed in the same direction. This fact by and large facilitated their integration. In addition, the qualitative investigation widened our horizon in that it brought detailed and sometimes hidden structures to the fore, which otherwise would not have been taken into consideration.

At any rate, the quantitative methods were an essential complement of the qualitative ones. They were not conceived as a mysterious calculus, leading to a figure about costs and benefits at the end. On the contrary, the result was a clear quantitative account which translated the qualitative deliberation into economic figures. Assumptions were specified throughout; the whole calculus was transparent and capable of being duplicated.

In addition to the relatively static calculus, a dynamic model was constructed which showed the long-term dynamics of the socio-economic evolution of the valley. That model showed that the results of conventional calculations underestimated the fatal consequences of the planned intervention. The insights triggered by the simulation results raised collective awareness within the forum.

As is usually the case with this kind of study, not all aspects can or should be quantified [Vennix 1999]. Therefore, the calculations were complemented by the additional qualitative arguments. If we had worked only qualitatively, it would have been much more difficult to take a decision, which is generally the problem with "thick descriptions" [Geertz 1993]. Had we worked only quantitatively, however, the basis for the decision would have been narrower and incomplete.

Altogether, this was a case of applying systemic thinking to a complex situation and thereby generating superior results in comparison to what might have been achieved with traditional approaches.

Most important, though, is what remains once the method has been accounted for. The study was a vital ingredient in the decision-making process, and ultimately proved to supply a crucial argument for choosing the most beneficial, although most demanding, of the variants. The implementation of any other variant would have had a negative impact on the valley in social, economic and ecological terms. Depending on the variant, that impact would have ranged from dangerous to disastrous.

In this sense it is no exaggeration to claim - *cum grano salis* - for the case in point: A valley was saved by means of a system study.

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