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The exploratory analysis of trade-offs in strategic planning: Lessons from Regional Infrastructure Foresight

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ABSTRACT

The sustainable transformation of infrastructure sectors represents a challenge of prime importance worldwide. Due to long life times of infrastructures, strategic decision making has to explicitly consider uncertainties in context conditions, value considerations and available technological alternatives. However currently, strategic infrastructure planning is often carried out in a very narrow perspective. The present paper argues that foresight informed strategic planning, allows addressing trade-offs related to context uncertainties, value conflicts and sustainability deficits in a structured way. The paper introduces a specific procedural proposal, the Regional Infrastructure Foresight method (RIF) and illustrates its potential virtues through an application to urban water management planning in a Swiss region (Kiesental).

1. Infrastructure planning and foresight

In OECD countries, most infrastructure sectors such as electricity supply, water supply and sanitation were constructed over the 20th century by implementing a narrow socio-technical paradigm of central generation plants with wide area distribution networks. The presumed superiority of this paradigm relied on a series of assumptions, like the predictability of the socio-economic development of the supplied region [1], the predetermination of the technical option, and the politically set criteria of effective, homogenous and affordable infrastructure services [2].

It is fair to say that this socio-technical constellation has been highly successful over the past decades. Nowadays, infrastructure organizations are confronted with an increasing amount of future uncertainty [3] that calls for a fundamental reconsideration of the former success model, at least in three respects: (i) the context conditions are less stable and predictable due to increasing changes on the demand side and changing regulations, (ii) the available technical solutions offer new options to provide infrastructure services in a radically different form; and (iii) the criteria by which the optimality of the infrastructure is assessed have become more diverse and disputed.

Over the past decades, strategic planning in these sectors was mostly focused on narrowing down context uncertainties, value considerations and system configurations to reduce complexity and ease implementation [1,4]. Given the increased range of uncertainties, the recent literature has provided a number of new approaches and tools like modeling tools, real option approaches and decision analysis. However, these approaches are often deficient with regard to addressing the broad range of uncertainties associated with the long planning horizon (more extensively treated in [5]).

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Foresight has its strengths in addressing broad ranges of future conditions by adopting participatory and discursive approaches. Yet, in particular Technology Foresight has often been restricted to identifying future context conditions in order to scrutinize the robustness of specific strategies or as a means to identifying more sustainable futures. More specifically, it has focused on fostering cooperation and networking in science, technology and innovation policy [6]. Foresight is however much less well developed in strategic planning contexts as it often misses the link between analyzing uncertainties to assessing options and suggesting implementation strategies [7].

In the present paper, we want to build on foresight methods for improving strategic decision making in infrastructures through the method of Regional Infrastructure Foresight — RIF. Relative to Technology Foresight, we emphasize the implementation side of socio-technical systems, i.e. we want to analyze under which conditions the receptiveness for innovative solutions could be increased, especially in contexts that are otherwise rather averse with regard to innovation [8]. Foresight methodologies should therefore not only inform the identification of future context conditions but may also be applied to future system options and preference structures. Such a methodological framework is likely to depart — in style and content — from the currently dominant forms of strategic decision making in infrastructure sectors [5]. While in conventional approaches, reduction of uncertainties was the guiding principle for structuring the decision problem, we will propose a foresight based approach that allows for considering a maximum range of uncertainties. This enables the identification of the major trade-offs associated with context uncertainties, newly emerging technological solutions and potential future interest conflicts associated with the implementation of specific system configurations. Finally, we will also address the issue of sustainability deficits of decisions: how to anticipate and integrate them into the formulation of a long term management strategy for infrastructure development.

We will present empirical evidence to support our claims from the experiences of implementing the RIF method in the Swiss sanitation sector. As the sustainability of the established technical system has raised some criticism [9,10], new solutions to urban water management are discussed more widely today. Sanitation services are mostly provided by public organizations and strategic planning is mostly carried out in a very narrow perspective: tending to blind out alternative solutions, context uncertainties and broad goals. We therefore consider strategic planning in sanitation as an appropriate test domain for the methodology. A similar approach has been presented by Dominguez et al. [2]. They utilize infrastructure foresight to identify technological and organizational capability deficits. In the present paper, we aim at explicating the contribution of the foresight approach to the identification of trade-offs.

The argument of the paper develops as follows: In the next section, we lay the ground for combining strategic planning in infrastructures with foresight methodologies. Section 3 presents the procedural outlay of the Regional Infrastructure method and introduces concepts for addressing the trade-offs relative to context uncertainties, conflicts and sustainability deficits. Section 4 presents the results from the application of RIF in the Kiesental region in Switzerland. The final section gives an outlook on further application domains for foresight and strategic planning in infrastructure sectors.

2. Breaking up path dependencies in strategic infrastructure planning

2.1. Characteristics of infrastructure sectors

Infrastructures represent a specific challenge to strategic planning methods. Due to the long life time of their key technical components and the strong coupling between technological and institutional structures they exhibit strong path dependencies [11]. They are particularly strong in OECD countries where infrastructure networks have been established since decades. In the social science literature, the couplings have been described as socio-technical regimes. They consist of rules, standards, scientific knowledge, engineering practices, technologies and skills that determine a stable context in which highly complex system configurations can develop [12]. Socio-technical regimes create advantages for system development as they tend to reduce the costs of knowledge generation and the political costs of decision making [13]. However, the structure of the socio-technical regime also tends to blind out more radical socio-technical alternatives and favors incremental improvements [1,4,5]. For instance, a historical analysis of the emergence of the currently dominant socio-technical regime in wastewater treatment is elaborated by Geels [14].

As infrastructures are often public services, their operation and maintenance are strongly dependent from policy and mostly delegated to the local or regional level. Particularly in public organizations there is often a wide lack of capabilities for running strategic planning processes [2]. Additionally, network infrastructures have a clearly defined spatial extension and are of key relevance for economic development, human wellbeing and locational advantage for industry and citizens of a specific region. Therefore, infrastructure planning has to incorporate an explicit political dimension as well as a wide range of actors with diverging interest positions. Given the long life times of most infrastructures, strategic investment decisions will only take place every couple of decades. As a consequence, these decision making processes are often non-routine, badly structured and complex [15].

Due to the long term horizon of infrastructure decisions, the planning process has to deal with lately increasing uncertainties in different fields. Firstly, uncertainty in context conditions has been increasing substantially due to changing regulations, rapid urbanization and shrinking rural regions as well as market liberalization [3]. Secondly, the range of possible technological system alternatives has been substantially expanding. Due to ICT, miniaturization of components, new technological solutions like membrane technology or new measuring and control devices, radically different system configurations might become available with grossly enhanced performance characteristics. And thirdly, the criteria by which the optimality of system configurations is assessed have been becoming more diverse and disputed. For almost one hundred years in industrialized countries, infrastructure organizations have been optimizing to guarantee the provision of homogeneous and affordable services. Today a balanced consideration of environmental, social and economic aspects is necessary [16].

Strategic planning processes are a key for determining the appropriateness, performance and sustainability impacts of infrastructures over their long life time. Changes in context conditions outside the considered range may entail very costly adaptation measures (see e.g. [17]), potentially reversing the originally developed preference rankings for system alternatives. Furthermore, as infrastructures represent the back-bones of industrialized societies, citizens and industry are fundamentally affected by their proper functioning. When evaluating system alternatives, a wide set of potential impacts has to be considered in order to define a socially optimal outcome. Given that challenges are increasing in infrastructure sectors worldwide, a more elaborate and open approach to strategic planning seems very timely.

2.2. Foresight supporting infrastructure planning

Foresight methods have been developed over the past decades to explicitly address substantial uncertainties in technology development. Therefore, we may assume that strategic planning in infrastructure sectors could substantially profit from insights gathered in this tradition. Following a widely shared definition, foresight aims at improving future-oriented decision making through the early detection and assessment of emerging trends and drivers of change [18]. In its applications it has contributed to the analysis of future development options of nations, regions, sectors and companies mainly by focusing on perspectives associated with new technology development. Furthermore, its standard case of application has been to direct and prioritize science, technology and innovation policy measures. While the earlier approaches tended to be techno-deterministic, the later applications more explicitly address the co-evolution of technology and society [19]. In line with this shift of attention, foresight was mainly conceived as an “informing policy” task until the 1970s, and has been expanded into a systemic support instrument for policy formulation and implementation more recently [20].

More specifically, foresight related thinking was applied to three key elements of decision processes: context conditions, options and value considerations. Many applications focused on exploring broad ranges of possible future context conditions. Additionally, strategic options were assessed in relation to specific scenarios [21]. Whereas foresight has often been run in participatory settings in the past, an explicit consideration of differing value perspectives is more recent. We will elaborate these three aspects in some more detail below.

(1) Exploratory context scenarios analyze a set of possible future framework conditions relevant for organizations, regions or communities. Mannermaa [22] calls these hermeneutic studies, that aim at explicating a subjective understanding of possible future social realities. These explorative external scenarios [23] typically span a wide range of possible developments of context factors that are beyond the control of the relevant actors. The aim of these foresight processes is to gain better understanding about shifts in framework rules in order to better prepare today's decisions and anticipate risks of established strategies [24,25]. The elaboration of scenarios supports self-reflection and learning as well as strengthens strategic thinking [26] by challenging individual and organizational worldviews [27]. According to e Cunha et al. [28, p. 943], “[f]orward-looking knowing threatens the comfort arising from established routines and dominant logics”. In land-use planning, Xiang and Clarke [29] speak of “learning scenarios” as vehicles for better specifying preferences for specific “ends”. Context scenarios are especially important in the case of infrastructures as there is a high interdependence between the long term oriented infrastructure and its regional context [30].

(2) Other applications of scenario planning are framed as decision support instruments for the assessment of strategic options: Basically they explore the ranges of consequences, outcomes and impacts of strategic decisions and corresponding actions. Xiang and Clarke [29] call them “decision scenarios” with a focus on “means”. In corporate contexts, innovation oriented foresight focuses on long term product development strategies or market prospects. Here, foresight is geared towards ‘exploration’ of longer term strategies in innovation management [31]. Mannermaa [22] emphasizes its role for increasing the scope of strategic alternatives in order to allow for exploring consequences of “impossible” strategies, [23] including disruptive alternatives. Cagnin and Keenan [19] dub this type of approach as mode 2 foresight that allows the consideration of fundamental changes in paradigms, which contrasts with mode 1 that focuses on the improvement of existing systems. Mode 2 foresight “is about questioning the existing system, initiating disruption, undermining existing world views, and raising the spectre of the incredible” [19, p. 6]. Potential solutions have to be critically reflected against the broad background of context scenarios and specific trade-offs must be identified [32,33].

(3) The outcome of an assessment of options in the context of different scenarios still depends on the type and weighting of assessment criteria that are applied. In infrastructure sectors or other projects of public interest the range of goals is likely to be very broad and the relative importance attributed to different goals will vary depending on interests of specific stakeholder groups' perspectives [34]. Linstone's “multiple perspectives approach” [35] argues for the enrichment of the traditional technical system's analysis with organizational and personal perspectives. The variation of interests — and in parallel potential conflicts — increases with the consideration of political side effects of more radical solutions [36] as well as with different political and societal situations in context scenarios.

Foresight and scenario planning have been applied to infrastructure sectors in different forms. As a benchmark, we will briefly review typical applications in the field of transportation as this represents the most widely addressed empirical application case. Land use–transportation scenario planning projects have been carried out since the late 1980s in the US [37]. In particular metropolitan transportation “has moved from a supply-side focus — siting facilities to meet projected demands — toward a more integrated system- and demand-management perspective" [38, p. 4]. Some scenario projects show a variety of different land use or transport technology scenarios without explicitly assessing adequate strategies [39–43]. Others include the assessment of options but do not explicitly embed the planning in political decision making processes and are not explicit with regard to different stakeholder preferences [38,42,44–51]. A meta-analysis of 80 scenario processes in the U.S. found that these processes were started with a clear idea of the desired results, did not include stakeholders sufficiently, used inadequate assessment methods and failed to conclude the process by actually informing strategic action [37].

2.3. Framing a "strong" exploratory approach to strategic planning

Based on these experiences, we may now frame the problem of informing strategic infrastructure planning by foresight as follows: Given that conventional planning approaches are optimized for blinding out uncertainties in contexts, system alternatives and value considerations, we propose to apply a "strong" exploratory perspective to these core elements of the strategic planning process. Via the exploratory approach, the amount of uncertainty considered will be increased: (1) opening critical context developments, (2) broadening the range of analyzed system alternatives, (3) using sustainability criteria and stakeholder preferences for the assessment and making impacts of system choices transparent. To tackle this claim in an adequate way, a widening of participation in the assessment phase is necessary to include local knowledge for the establishment of regional specific scenarios [6] — as well as for multi perspective assessment of options. In terms of methodology, the value driven assessment follows the multi-criteria analysis approach (e.g. [52]) which is expanded to include uncertainties of context conditions (see e.g. [53]). The proposed process thus follows the model of an analytic–deliberative decision making process [54].

As a result, these procedures will most likely not provide very specific recommendations which can be directly implemented. However, strategic decisions are taken in a higher degree of reflexivity and transparency through the explicit consideration of the relevant trade-offs. In particular, we expect that this approach enables decision makers to systematically ponder a broader spectrum of system alternatives (especially those including development options outside the dominant socio-technical regime), to pro-actively reflect on consequences of changing context conditions and to more explicitly evaluate trade-offs associated with specific value considerations. By considering all these aspects, we posit that more sustainable development strategies for infrastructures will result. Foresight, according to this understanding, is not planning itself, but is rather an important first step in an overall strategic planning process (Coates 1985 cited in [25]). We therefore accept the call of the "Adaptive Foresight" approach [7, p. 464], that "there is a need to move a step beyond collective processes and to guide decision making of individual actors if foresight is to have a real impact". We take this proposition as a strong invitation to explicitly specify the organizational and procedural interfaces between the exploratory phase in a strategic planning process and the utilization of selected assessments' results.

3. The Regional Infrastructure Foresight method

In view of this specific problem constellation and based on the theoretical arguments introduced above, the authors elaborated and tested a specific method for strategic infrastructure planning, the Regional Infrastructure Foresight method (RIF). RIF aims at providing an explorative perspective on strategic decision making and adopts an explicit participative stance. This approach is conceived to provide orientation, target, and action knowledge [55] to the decision makers and render the major trade-offs that could appear over the lifetime of an infrastructure transparently.

The method was developed and tested in a transdisciplinary research project that empirically focused on the Swiss urban water management sector. Following the model of action research [56], the project team was not only involved in devising and specifying the method but also acted as process facilitators and moderators of the workshops and sessions in the empirical application cases. In this section, we will introduce the procedural structure of the method: deriving trade-off mappings related to context uncertainty, potential interest conflicts and sustainability deficits and utilizing the results in the formal decision making process (Fig. 1).

3.1. Structuring exploration: procedure and methods

The steps of the RIF procedure are sketched in this section according to the phase model from Miles and Popper [57,58].

3.1.1. Pre-foresight and recruitment phase

In the pre-foresight phase, the overall aspirations of the RIF process are defined: to analyze context conditions and system alternatives for an infrastructure system in the time horizon of 25 years which is congruent with the expected average lifetime of central infrastructure components. The territorial delimitation is defined by the current spatial perimeter of the infrastructure system and may be enlarged for the identification of promising options. The RIF process typically runs for nine months during which several working groups interact in a highly structured way.

In the recruitment phase, the decision makers commission — supported by the process facilitators — a core team of approximately half a dozen representatives from the political decision making bodies and other relevant infrastructure experts to run the central analytical steps of the procedure. For selected process phases, a wider group of stakeholders is involved [59] to diversify the knowledge sources [30]. The relevant groups are identified in the situation analysis (e.g. by using system constellation methods [60] to identify the roles, intentions, power and interactions among the most influential and affected actors). The core team selects approximately a dozen stakeholder representatives according to their influence and affectedness [61]. The core team meets monthly to elaborate the main analytical steps and to evaluate workshop results. The stakeholders are included in two workshops. At the end of the process, the results are transmitted to the decision makers who then decide about specific strategies.

3.1.2. Foresight generation phase

In the generation phase, the exploration of context uncertainties, values and options is highly structured. First, the core team elaborates a system representation of the regional wastewater system. Based on an analysis of technical reports, board minutes and stakeholder interviews, they identify the strength and weaknesses of the prevailing technical and organizational set-up to address claims from customers, public, regulatory bodies and the affected environment [62]. The core team analyzes the influential factors that are region specific: context factors like economic, demographic and settlement development, future political culture and environmental regulations. They select the most influencing and uncertain factors for further analysis.

During the first stakeholder workshop the participants project different possible states of each of the factors in the year 2030+ of each of the suggested influencing factors. The participants select three to four scenario cores from the analysis of regional and regulatory developments. They construct the context scenarios for the year 2030+ discursively by describing coherent and plausible scenarios that are regional specific [63,64].

Secondly, the core team systematically evaluates the impacts of these context conditions on the infrastructure system relative to an encompassing list of performance goals. To avoid an unreflected narrowing of specific goals, a systematic sustainability value tree (e.g. [65]) is used as a reference.

Thirdly, the set of potential system alternatives is systematically explored. Options are regarded as combinations of technical and organizational system characteristics that cover the entire process chain of the infrastructure service [64].

Fourthly, the assessment of the options follows the well established method of sustainability value tree analysis [66,67]. Value preferences are made explicit by weighting the attributes of the tree. The evaluation of options is first carried out by the core team applying the different criteria in a balanced way for each scenario. The resulting ranking orders can be interpreted as the experts' judgment of the sustainability performance of each option. In the second stakeholder workshop, the perspectives of relevant stakeholder groups are taken into account. For each scenario, participants adopt roles of different future stakeholder groups — representing either future citizens or industry representatives — define their assumed preferences and rank each option on an ordinal scale ranging from “well suited” to “not desirable”. In the end, a list of assessments will be available for each option under each scenario and evaluated according to the preferences of each considered interest group.

3.2. Exploring the landscape of trade-offs

These results may then be analyzed via different perspectives. We propose three differentiations that can inform decision makers about potential trade-offs associated with a specific option: (i) the dependency of option rankings relative to different context conditions, (ii) the level of conflict among stakeholder groups that a certain option would entail and (iii) sustainability deficits of preferred options.

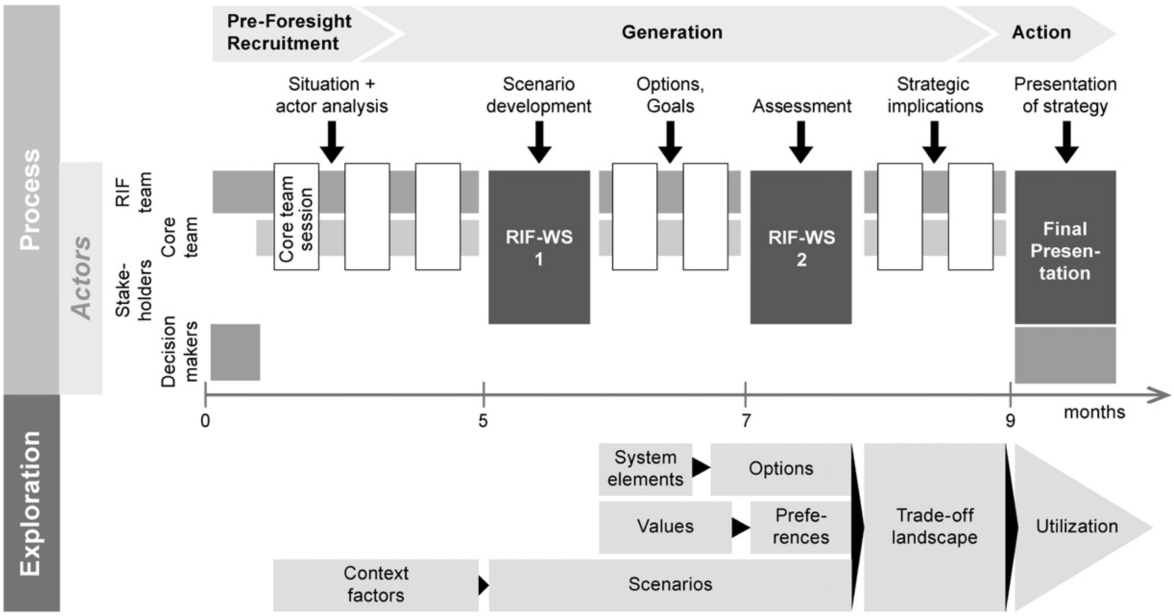

Fig. 1. Process, participation and exploration flow chart of the RIF process.

For analyzing these trade-offs, we have developed two graphical representations of the assessment data. The first one relates "social preference" for each option in each scenario to its potential social conflict level (see Fig. 2). For simplicity's sake, we chose to average the ordinal preference values that the different interest groups attributed to each option in each scenario as an indicator. Conflict potentials were in turn interpreted as the sum of absolute differences between the values. According to this definition, options can be posited in a triangular way.

The triangle may be further divided into different subareas, represented by the dotted-line circles. Options in the upper left corner can be assumed to have a high probability of implementation because they have a high social desirability and entail little conflict. Those in the lower left corner tend to be discarded because stakeholders agree on their low performance. Options in the far right corner show strong differences in assessments among stakeholder groups. Hence, decision makers should be aware of potential divergence of interests. The higher middle circle encompasses options that were very positively assessed by one group but found only lukewarm support by the other. This may indicate risks that have to be considered before implementing the solution. The lower circle calls for some caution in discarding these options because arguments for a more favorable assessment had been raised at least by one stakeholder group.

Trade-offs related to context conditions and diverging value perspectives can now be represented in this diagram for each option. The diagram allows pinpointing ambivalent situations that need a more reflexive consideration. This becomes even more obvious if dependency on context conditions is considered which is graphically represented by connecting the performance scores of a specific option under different scenarios by a polygon (see Fig. 2). Size and location of the polygon can directly be interpreted as a measure of context and interest dependency. By comparing the different polygons, one can derive context and conflict sensitive social preference orders (see Section 4 and Fig. 4 for empirical illustrations). For easy communication this representational device has limits: no attention is given to unequal power relations between the stakeholder groups or different possibilities of realization for each scenario. However, these aspects can be taken into account in the interpretation of the specific empirical data.

Strategic choices based on the above listed arguments take into account uncertainties in context conditions and interest constellations. While we may imagine solutions that seem attractive to a majority of the stakeholders in a future regional setting, this can only occur at the expense of a "third" party (e.g. by entailing substantial environmental impacts). Or put in other words: socially optimal solutions may still exhibit substantial sustainability deficits. In order to consider the latter, we introduce a second visual representation of the data (see Fig. 3). As a first dimension, we chose again the social desirability of each option, measured by the average of the stakeholders' ratings. As a second dimension, we add the ratings attributed to each option by the core team in their effort to consider the different sustainability criteria in a balanced way. In other words, we may say that the (prospective) stakeholders assessed the options according to their (assumed) subjective interests, whereas the core team tried to identify the sustainability performance of each option on a more "objective" (i.e. balanced) basis. The location of options in Fig. 3 may now be interpreted as follows: a coincidence of social and sustainability assessments is given if points are located in the diagonal area pointing to the upper right corner. Points to the left of the diagonal indicate potential sustainability deficits as the option is more desirable from the average stakeholder groups' perspective than from a balanced sustainability perspective. Points in the lower right corner represent options that are rated low by stakeholders but would rank higher if a more balanced consideration of goals was taken into account.

A final note of caution is appropriate when interpreting these two diagrams. They are highly condensed graphical devices synthesizing the trade-off structure among the options as they were elaborated in the different workshops. Actual strategic implications should therefore be based on the explicit arguments that have been raised in the core team and workshop discussions. The diagrams remain almost meaningless if isolated from this content. On the other hand, the vast amount of discursive material assembled during the nine month process is very difficult to grasp and communicate to those that did not

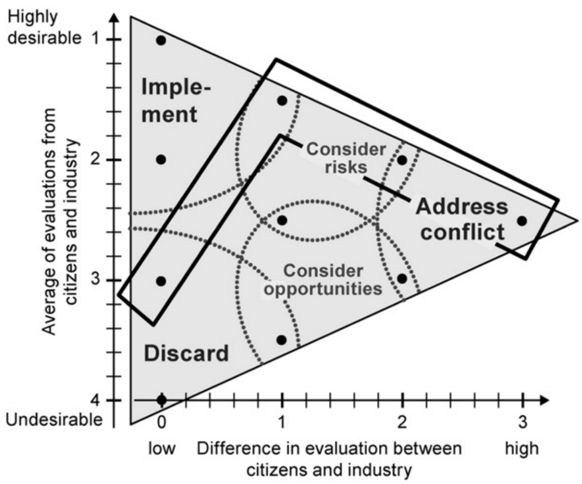

Fig. 2. Desirability–conflict diagram.

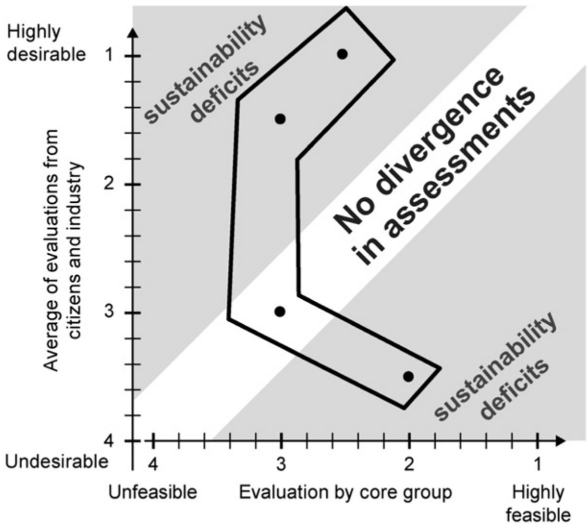

Fig. 3. Identifying sustainability deficits.

participate in the different stages of the process. Here, the diagrams may fulfill an important role for communicating the core relationships and trade-offs.

3.3. Utilization: uncertainties, trade-offs and decision making

The data generated in the workshops and core team sessions are finally synthesized by the core team into a recommendation for strategic planning. For each option, strength and weaknesses of performance under widely varying context conditions can be specified. Based on this argumentative material, the core team may narrow down the options to one or two system alternatives that show a high sustainability potential. Depending on the respective uncertainties, strengths and weaknesses of the options, new sub-variants may be formulated that (i) would be less vulnerable to critical context conditions, (ii) would help to compensate for potential sustainability deficits, (iii) enable pro-actively addressing future conflicts of interest and (iv) profit from new technical options potentially emerging in the course of the lifetime of an infrastructure system.

This synthesis does still not forestall the final strategy formulation through the decision makers. It rather circumscribes promising search directions for future system configurations and thus allows escaping the path dependencies encountered in conventional planning processes. The report of the core team is finally handed over to the political decision makers in a final presentation accompanied by the workshop participants. As members from the decision making body have participated in the core team, a proper transmission of the facts and arguments gathered throughout the RIF process should be guaranteed [7].

4. Case study Kiesental

In the following section, we want to illustrate the individual steps of the procedure by presenting experiences gained in a specific pilot case in the Swiss sanitation sector.

4.1. Strategic planning in the Swiss sanitation sector

The Swiss sanitation sector can be considered a success story of environmental policy making. Connection rates of households to centralized wastewater treatment plants rose from form 15% in 1965 to 97% in 2005. As a consequence, water quality improved considerably in all major rivers and lakes. The assets built up during these decades amount to approximately 100 billion Euros [68]. Today, however, there is a high need for repair and renewal.

The sanitation system has limited flexibility to adapt to changing context conditions as its key technical components have a very long life time (e.g. sewer system last 80 years, wastewater treatment plants last 25 years [17]). Communities own and operate most of the sanitation systems. Strategic decisions are taken by political delegates who rely on advice from their operators, consulting engineers and regional and national regulatory bodies. The highly localized and fragmented character of this organizational structure is illustrated by the fact that each of the 2500 communities runs their sewer systems and 700 organizations run 760 wastewater treatment plants. Therefore the responsible operating organizations are rather small to medium-sized; they are focused on the operation of the technical system rather than on the management of the integrated sanitation system. As a consequence, they often lack professional structures and strategic competences. Commissioners of strategic planning processes are mostly interested in low investment costs or low overall costs, while the regulatory agency is concerned with water quality. The focus of planning processes is mostly based on technical solutions.

Based on a national analysis of the Swiss sanitation system [69] and a call for participation in innovative strategic planning processes, three more or less representative cases for small to medium-sized sanitation systems were selected as pilot cases of the RIF method. These cases were run between late 2006 and early 2008. In the next section, we present the process and results of the "Kiesental" case that allows illustrating the different elements of the method and its implications.

4.2. Initial situation in the Kiesental

The Kiesental region (i.e. the catchment of a stream called "Kiese") encompasses a rural area with 26 communities and 26,000 inhabitants located between the two cities of Berne and Thun. Four public wastewater treatment organizations are independently responsible for each small to "lower medium-sized" wastewater treatment plant with a capacity between 7000 and 25,000 inhabitant equivalents and a workforce of one to 2.5 full time equivalents each. The plant operating organizations are associations of communities, while sewer networks are owned and operated independently by each community. Three wastewater treatment plants have been renovated recently, while the fourth was challenged by massive demand reduction.

Two arguments proved to be important motivations for the Kiesental to participate in the RIF process: (i) After the closure of an industrial butchery, it had become necessary to shrink one of the plants to half its capacity. Alternatively, the decommissioning of the plant and a merger with the downstream organization was discussed. (ii) The sanitation associations are small and thus lack employees to guarantee 24 hour availability. Therefore, the idea of an organizational integration of the associations had been raised. Political actors of the region were keen on developing a "perspective" for the future of the sanitation system to avoid singular investments, which could prevent and defer the establishment of more appropriate structures of the sanitation system in the future. The regional development association of the Kiesental, which already initiated a valley-wide water supply and also a flood protection organization, took on the task of organizing a working group and exchanging perspectives about the sanitation system in the region.

4.3. Constructing the trade-off landscape

Based on this initiative, the regional association decided to run a pilot RIF case to explore and assess different cooperation strategies within the region of the hydrological catchment of the river Kiese and the neighboring part of the Aare valley. The core team encompassed two representatives from the regional development association, one from each of the regional sanitation associations, plus one representative from the regulatory body of the cantonal water protection agency. Except for the cantonal official, all were technical lay people but experienced politicians in the field.

The core team analyzed the prevailing technical and organizational configurations. The technical quality of the wastewater plants was rather high but the sewerage was ramshackle in certain places. Only two of the organizations were judged as operating efficiently. Very little cooperation existed among these organizations. The sanitation system was constructed in a way to accommodate the needs of two heavy polluting industries.

In addition to technical and organizational aspects, the core team surveyed the actors in the regional sanitation landscape to select participants for the stakeholder workshops. As a result, fourteen people representing the most influential and affected groups of the sanitation system were invited: representatives of wastewater treatment organizations, citizens and politicians of specific communities, industry representatives (especially heavy polluters and industry lobbyists), regional planners, and representatives from neighboring regions.

In the first workshop, the stakeholders elaborated four alternative scenarios describing context conditions in the year 2030+ based on the set of influencing factors which were prepared by the core team: (I) The "high quality of life region" with a majority of citizens favoring a sound environment. Yet this is also characterized by high water consumption and a rather high willingness to pay for infrastructure services. (II) The "powerful region" scenario with effective regional collaboration and secure employment in industry and farming. In this scenario there is only little migration within a strong middleclass segment and local industry and farmers. On the other hand, new water regulations require the removal of micro pollutants. (III) The "top/flop" scenario describes a downturn of industrial activity in the region. Inhabitants of peripheral areas leave the region while centrally located villages experience an increase of commuters to the city of Berne. Overall, tax income tends to decrease in this situation. (IV) The "downturn of the Kiesental" scenario is characterized by job loss and emigration. The situation gets worse with increased pressures from climate change like floods and droughts. This also leads to a decrease in farming activity.

In the next step, criteria for assessing system performance were identified. Sanitation was originally implemented as a means to guarantee hygiene and improve health conditions and later on to minimize impacts on aquatic ecosystems. Furthermore, the infrastructure as a public service had to guarantee equal access and affordable tariffs to all citizens. These economic, ecological, social and governance objectives were elaborated in more detail and specified for the region. The different scenarios were then analyzed in order to determine their sustainability challenges. For example, the downturn scenario showed an increase of the environmental impacts of untreated wastewater overflows during heavy rain events. Health might therefore be threatened when hygienic standards declined in a dire economic context. Cost minimization would receive a high priority whereas at the same time it might be politically difficult to implement full cost pricing schemes.

In the following step, a set of options was developed by the core team, based on varying technical and organizational characteristics of a future wastewater system: e.g. degree of technical centralization, scope of services offered by the organization (s), and organizational structure. Out of these core elements, three potential system configurations were elaborated: (A) The option "umbrella organization" focused on reaping synergies by establishing an organizational superstructure while maintaining the prevailing technical structure and the autonomy of the existing organizations. (B) The option “merger” described a full organizational merger with the long term ambition to also technically centralize the sanitation structure. (C) The option “onsite treatment” foresaw a stepwise introduction of onsite wastewater treatment devices for single houses or small neighborhoods and the reduction of sewer systems functions to evacuating surface water.

The options' assessment took place in two steps. (i) The core team assessed the options' generic strengths and weaknesses in reaching sustainability goals in a well balanced way for each of the different scenarios. (ii) In the second workshop, participants carried out the same assessments by taking the perspective of typical future citizens or industry representatives. For instance in the downturn scenario, citizens were characterized as being rather over-aged, modest, conservative, and attached to their region, earning medium to low incomes mainly from farming, small businesses and social welfare. These were assumed to favor low tariffs, public subsidies to keep the system going and indiscriminate access to sanitation services. Environmental impact ranked only second in their priorities. In contrast, the industry's stakeholders favor besides low tariffs, additionally low levels of bureaucracy as well as voice and participation in the associations decision board.

4.4. Exploring the trade-off landscape

The virtual future stakeholder groups assessed the options according to their assumed goal preferences. Citizens in the downturn scenario, for instance, claimed that onsite treatment represented the most desirable solution because maintenance costs would be low and the sewer network could be dismantled outside dense settlement structures. However, some caveats about the performance of these future technologies in more densely populated villages were also raised. In contrast, industry stakeholders did not favor this option, mainly because they would have to treat their wastewater onsite which is not part of their core competences.

The desirability–conflict diagram resulting from these assessments is presented in Fig. 4. The general picture shows that all three options are characterized by extensive polygons which implicate a strong context dependency and that consensus between the stakeholders is often lacking.

The “onsite treatment” option received highly diverse assessment scores. Strengths include the replacement of the cost intensive sewer network and the flexibility of the system, especially under “downturn” and “top/flop” scenarios. Weaknesses incorporate the uncertainty about system reliability of the technology and uncertainties associated with service reliability, potential problems with quality control and the risk of creating new strong path dependencies. In the “downturn” scenario, assessment results were rather antagonistic. In the “high quality of life” and the “powerful region” scenario, both groups ranked the solution as rather problematic or not desirable. In the “top/flop” however, both groups saw it as a rather positive solution.

The option “umbrella organization” was generally perceived as being beneficial because it provides a better regional coordination, synergy effects, high acceptance, and fast applicability. Some concerns were related to a long term increase in tariffs, complicated labor intensive organizational structures and inflexibility of the existing treatment capacities. Especially in the downturn scenario, this option seemed to lead to high organizational complexity with insufficient benefits.

The “merger” option was strongly favored by industry and in two scenarios also by the citizens. This was aligned in line with the assumption that this option would lead to high efficiency in operational terms due to a professionally organized central corporation

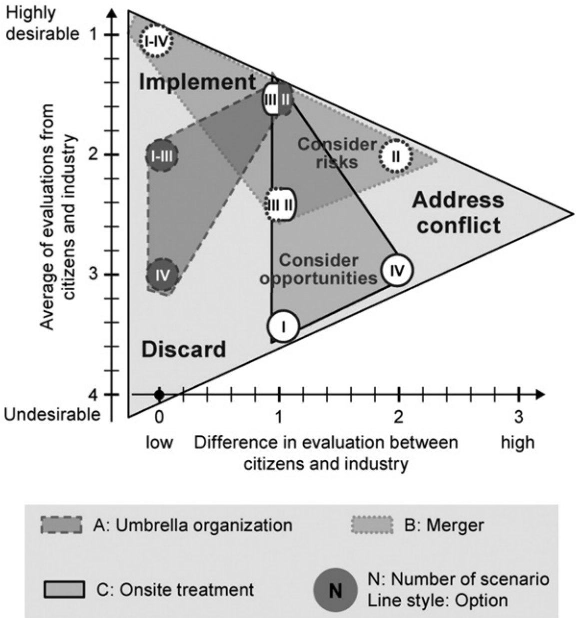

Fig. 4. Desirability–conflict diagram for the three options in the Kiesental case study.

and a forceful coordination of regional sanitation services. Citizens in the "powerful region" scenario, however, criticized the limited possibility for participation and in the "top/flop" scenario they were afraid of a disconnection of peripheral areas.

A comparison of the stakeholders' assessment with the sustainability evaluation of the core team offers insight into the sustainability deficits that a politically negotiated solution would entail (see Fig. 5). If we look at the "onsite treatment" option as an example, we can detect favorable aspects neglected by the stakeholders: In the downturn scenario, the core team assessed "onsite treatment" as the best solution due to savings in the sewerage network, water recycling during droughts, reduced storm water overflow during extreme rain events, etc. In the case of the high quality of life scenario, the possibility to recycle water was very important from an overall point of view, a characteristic that was not taken into account by the stakeholders. Such sustainability aspects could thus be included into the elaboration of detailed recommendations in the next step.

4.5. Utilization — implications for infrastructure development

The performance characteristics of the different options and the associated trade-offs were taken into account by the core team for formulating their strategic recommendations. They assumed that the current political resistance against the merger option would be quite important, a transitory organization would be necessary to implement a stepwise decision process taking place over one or two decades. The "umbrella organization" was considered as a first step on this longer journey. Closer cooperation and coordination could easily be implemented in this form, while the risk of building up too much organizational overhead could be minimized.

Furthermore, critical framework conditions were taken into consideration. Climate change effects with extreme weather events might impact the receiving river and considerably increase the cost characteristics of the centralized system. For this reason, the core team recommended that the introduction of onsite treatment facilities should be seriously considered in future maintenance and expansion plans. One implication could be that the sewer network expansion to new peripheral settlement areas might be stopped and a downsizing of the network should be considered in case major renewals in the sewerage would become necessary. Another recommendation was that in the long term, central wastewater treatment plants should exclusively be localized at the bigger receiving river Aare.

These suggestions were finally presented to the regional development association, which then elaborated a long term strategy towards a "merger". One year later, the political decision making process approved this plan that first foresees an intensified collaboration of joint human resource management leading to joint ownership of facilities and then paves the way for the establishment of a single organization.

4.6. Summary of the case study

In summary, we may state that the RIF process helped decision makers to develop a broader and deeper understanding of the challenges, of alternative solutions and of fundamental trade-offs that should be addressed for long term infrastructures planning.

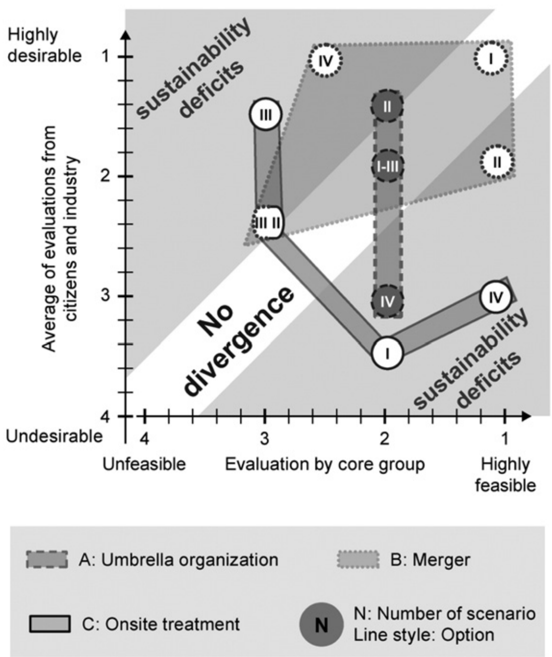

Fig. 5. Sustainability deficit assessment in the Kiesental case study.

The elaboration of a joint system representation by the different organizations in the Kiese catchment furthermore prepared the ground for intensified collaboration and shared visions. It must be noted that the solution developed in the course of the process was not entirely new to the participants. The need for increased collaboration or even a technical merger had already been identified earlier. However, it had been formulated as a vague vision that resulted mainly from a technical analysis of the current infrastructure components (unresolved problems in water quality, efficiency of the current wastewater treatment plants, organizational bottle necks in emergency situations, etc.). Optimization of the existing system components was the main target and not an analysis of the entire sanitation system. Political opposition along the way to a merger was expected but could not consistently be addressed in the conventional planning framework.

While the RIF process in the Kiesental resulted in little surprise with the already prior favored idea for a future sanitation system, it did lead to a more encompassing understanding of the challenges, interests, options and timing aspects of a conjointly favorable course of action could be elaborated. At the same time, open issues associated with the merger option could be identified and incorporated early on in a robust decision procedure able to respond to emerging information (e.g. concerning decentralized technologies), development of context conditions or changes in interests. One consequence was that decision makers departed from their initially strong position that only one big technical system was able to solve all future problems in the region. Instead, a broader range of options, even including radically different socio-technical configurations, was actually taken into consideration. Therefore, RIF provided a context in which uncertainties and trade-offs became a resource for decision makers to provide more robust solutions.

Two further case studies implementing the RIF approach were carried out in Switzerland: one in a rural area with an urgent need for investment in an old treatment plant. In this process the result was a radically different solution compared to an earlier recommendation gained in a conventional planning process less than two years earlier: The local wastewater treatment plant should be decommissioned and the catchment connected to the sanitation system across the board in Germany, a solution that had not seriously been taken into account before but reached high desirability and consensus in the RIF process. The other case study was run in a suburb of the city of Zurich with a high pressure of settlement growth and limited expansion capacities of the sanitation system opted for a strong professionalization option with potential expansion into other infrastructure services.

5. Implications and outlook

In this present paper we developed and applied an explorative oriented approach to strategic decision making in infrastructure planning. We argued that due to the long life times of key technical components of these sectors, a more discursive and open consideration of uncertainties in context conditions, values and options is needed compared to the established planning practice. We developed a specific methodological layout of a strategic planning process — the Regional Infrastructure Foresight method — that builds on a combination of foresight approaches that focus on exploratory context scenarios, option assessment and multiple perspectives. More specifically, we aimed at maximizing the uncertainties considered in the planning process. This enabled the process of explicitly mapping key trade-offs among different strategic options with regard to potential conflicts of interest, surprises in the development of context conditions and potential sustainability deficits. By carefully defining the interface between the foresight process and the formal strategic planning process, we could considerably improve the range of critical context conditions [7].

As experienced in our empirical application case, the insights gained by this approach were highly appreciated by the involved decision makers, despite the high level of complexity that became apparent in certain process phases. Members of the core team had to invest about seven full days over a nine months period for participating in the RIF procedure. This represents a heavy toll on time budgets of honorary working local politicians. Nevertheless, in the final evaluation of the process, they strongly welcomed the opportunity to conjointly develop the scenarios, options, value trees and to build up the argumentative structure represented by the trade-off mappings. The inclusion of selected additional stakeholders in the workshops was appreciated for tapping into a broader knowledge base and creating awareness for different value perspectives. Throughout the process, core team members built up a high level of trust among each other and with the results; thus they strongly supported the final recommendation submitted to the decision makers. The affiliations of the core team members in the decision making bodies guaranteed the persistence of the argumentative structure in later stages of the planning process.

After our rich empirical experiences, we believe that a strong explorative perspective can be combined productively with strategic decision making, provided that it is embedded in an appropriate procedural set-up and that different stakeholder perspectives are incorporated in a reflexive way (see also [7,30]). Furthermore, RIF offers an approach to explore disruptive alternatives in the mode 2 foresight concept. In this paper, we argued repeatedly that infrastructure sectors represent a special case for strategic decision making, particularly in the case of OECD countries. However, we have strong indications that certain lessons learned within the RIF processes have a much wider application domain than urban water management. In particular, it was stated by the participants that they faced similar decision problems in other domains of (inter-)communal services. Our methodological set-up is likely to be applicable in planning processes related to energy supply, schools, social services, hospitals etc. While the influencing factors and the basic sustainability criteria are similar to the one in the sanitation case, the options considered and the participants involved are likely to differ. A potential benefit of such an approach would be that regional development strategies could be tackled in a more encompassing way. For instance, region specific context scenarios could be created commonly in a first step, while sector specific options are developed separately in a second step and finally the solutions are integrated into a common regional strategy. Thus, regional development could be more intimately related to infrastructure planning in general.

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