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Intersections in delta development; analyzing actors for complexity-sensitive spatial concepts

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Delta areas can be considered complex adaptive socio-ecological systems. The Dutch Southwest delta, facing serious flood risks, vulnerability to ecological decline, and various challenging issues of agriculture, industry, harbor development and energy provision, is a case in point. Still, many institutional barriers exist towards governing and planning this complex whole as such. In this article we therefore develop and test a method for the development of integrative, complexity-sensitive spatial concepts: First, stakeholder analysis techniques are used to disclose the diversity of system understandings amongst the actors involved. Moreover, the method mobilizes these constructivist techniques to gain insight into the CAS property of co-evolving subsystems. Through the subsequent inventory, classification and synthesis of such 'intersections' between subsystems, the method helps identify the delta's crucial clusters of interdependent subsystems, or 'configurations'. We present three of such configurations, to illustrate how this method informs the step from systems analysis to spatial design.

Keywords: deltas, co-evolution, synchronization, actor analysis, spatial design, intersections

1. Introduction: Delta Complexity and The Need For Integrative Spatial Concepts

Delta areas can be considered complex adaptive socio-ecological systems. These areas are characterized by both morphologic and hydrologic dynamics, and by social complexity: Many actors (governments, non-governmental organizations, private organizations, etc.) at different scales (local, regional, national) have interdependent relationships (van Leeuwen & van Buuren, 2013). The Dutch Southwest delta, where the Rhine,

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Meuse and Scheldt rivers meet with the North Sea (see Figure 1 below), is a case in point: It is faced by serious flood risks due to climate change and soil subsidence, is vulnerable to ecological decline, and also involves challenging issues of agriculture, industrial and harbor development, and restructuration of the energy sector (Meyer, 2005). Actors in the delta area tend to cope with these issues in different and often isolated ways, however, and coalitions tend to focus on sub-topics: At Dutch national scale a Delta program has been installed which is primarily concerned with anticipating flood risks (Deltaprogram, 2011), the Rotterdam harbor authorities' developed a long-term strategy for port development (Havenbedrijf Rotterdam, 2011; see also Vanelslander, Kuipers, Hintjens, & van der Horst, 2011), and the environmental organization WWF develops a future vision of an open and ecologically vitalized delta (Wereld Natuurfonds, 2010). Besides these large-scale visioning and planning programs, a host of local, regional and interregional initiatives can be witnessed with regard to tourism, housing and small water-related companies (e.g. Dienst Landelijk Gebied, 2011; Intergemeentelijke Samenwerking Voorne Putten, 2011; Samenwerkingsorgaan Hoeksche Waard, 2009).

This collection of planning initiatives constitutes a considerable scope for meeting the delta's challenges. However the main problem is that (groups of) actors uphold their particular focus and scope, and accordingly develop their own partial solutions. Complex governance systems are often characterized by fragmentation, meaning that every actor (government, citizen, NGO, or private organization) has its own main perceptions and ambitions and approaches in analyzing issues and finding solutions (Folke et al., 2007; Edelenbos & Teisman, 2010; Termeer, Dewulf, & van Lieshout, 2010).

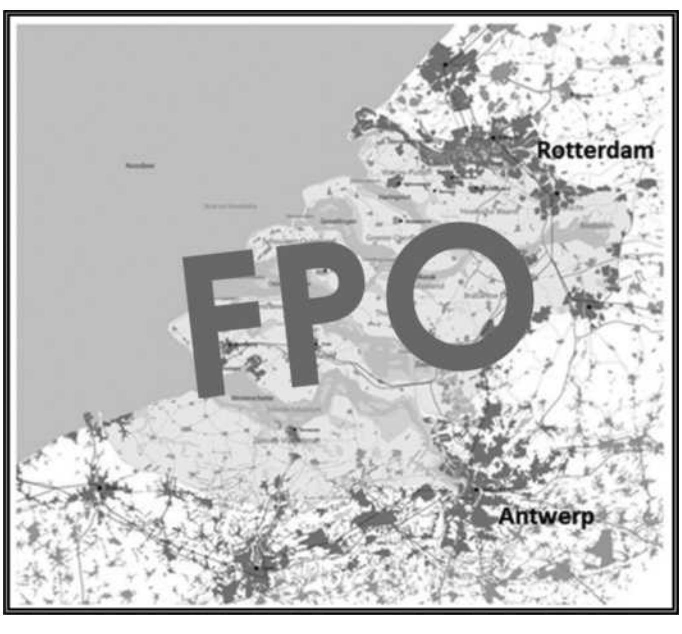

Figure 1. Southwest Delta

The visions of involved actors and their underlying system understandings prove insufficiently compatible in terms of geographical scale, temporal orientation, and sector ambitions. Involved actors are likely to diverge in their system understandings and subsequent problem definitions (Luhmann, 1995; van Meerkerk, van Buuren, & Edelenbos, 2013; Ulrich, 1983). This poses challenges to finding integrative concepts that ‘synchronize’ multiple issues in the area in such a way that these strengthen each other, rather than cancel out (Rammert, 2000; Edelenbos, Bressers, & Scholten, 2013; Pel, 2012; Teisman & Edelenbos, 2011). The main challenge for deltas can thus be defined as arriving at integrative spatial concepts through which perceptions, interests and ambitions can become aligned.

This article is aimed to develop and test a method for analyzing delta areas as complex adaptive systems (CAS), and for developing integrative spatial concepts (Zonneveld & Verwest, 2005) that are accordingly ‘complexity-sensitive’. This brings us to formulate our main question: *How does a method for analyzing delta areas as a CAS look like and how can this inform the development of integrative spatial concepts for these areas?*

We have answered this question by developing and conducting a particular kind of method of stakeholder analysis, which is aimed to disclose the diversity of perceived issues, problems and opportunities that arises at the intersections between the delta’s subsystems. Based on interviews and document analysis, we have drawn conclusions on the frictions and convergences (interferential and symbiotic intersections) between different system understandings. Synthesizing these typically multiple subsystem interactions, our intersections method has allowed us to establish three systemic configurations to inform subsequent development of integrative spatial concepts for the Southwest delta.

The article proceeds as follows: First, we outline our understanding of the Dutch Southwest delta area as a complex adaptive system (**section 2**). Subsequently we develop our methodology of intersections analysis. Combining CAS thinking with actor/stakeholder analysis, it helps identify the salient systemic configurations, as footholds for the development of integrative spatial concepts (**section 3**). Next, as a proof-of-principle, we describe three of those configurations **(section 4)**. Based on a comparison of these configurations, we discuss the scope and limitations of intersections analysis as inputs to complexity-sensitive spatial design **(section 5)**.

2. Delta Areas as Complex Adaptive Systems (CAS)

In the project ‘Integral Planning and Design in the Southwest Delta’ (Integral Planning and Design in the Southwest Delta, 2013), the delta is conceptualized as a complex adaptive system (CAS). It is treated as a dynamic and interconnected whole, with several physical and social subsystems as its co-evolving components. Crucially, these subsystems develop according to different development speeds and subject to distinct logics, which gives rise to the emergence of complex patterns and dynamic interactions among them (Uhl-Bien et al., 2007; Dammers et al., 2014). This CAS-conceptualization, and the associated decomposition into spatial layers and functional subsystems, is depicted below:

This systems model has been developed to foster interdisciplinary collaboration between researchers and practitioners in public administration, spatial design & planning, and geographical information systems. It has therefore been crafted to accommodate different professional requirements and applications, and to articulate different aspects of delta complexity. In particular, the model allows to grasp delta complexity both as the interplay between spatial layers, and as the interplay between social/governmental subsystems.

As regards the first, the model is based on the so-called ‘Dutch layers’ approach’ (Priemus, 2004; van Schaick & Klaasen, 2011; Döpp, Hooimeijer, & Maas, 2011). The Southwest Delta is conceived of as a complex formation that is built up from upward conditioning spatial structures. The three layers are distinguished by their different transformation rates: The physical substrate develops slowly, and as a relatively solid structure it sets the conditions for infrastructure networks and occupations (settlement patterns). Of the latter two, the layer of infrastructures typically conditions the development of various occupations and land-uses: Without draining, dredging and dike construction, for example, the Southwest Delta would hardly be habitable at all (van de Ven, 2004). Other than the natural forces of the substrate layer however, this infrastructural layer is man-made. As also theorized in Large Technical Systems literature, these sedimentations of human agency constitute path-dependencies but not deterministic forces (Hughes, 1994; Disco & van der Vleuten, 2002).

As a spatial model, the layers’ approach remains rather ill-equipped to articulate social and governance complexity, however. The model should differentiate further, at least reflecting that current governance is shaped by functional specialization, i.e. by administrative sectors. The layers approach has therefore been adapted to include a differentiation between societal subsystems. Hydro-infra, energy and transport constitute not only physically separated infrastructure networks, for example, they are also governed by different constellations of actors. These subsystem divisions, reminiscent of the societal subsystems distinguished in studies of socio-technical transitions (Grin, Rotmans, & Schot, 2010), bring the layers’ model in closer correspondence with the complexity of networked governance and fragmented sector policies (Teisman, van Buuren, & Gerrits, 2009).

Finally, apart from the layers and their subdivisions, the above systems conceptualization theorizes general trends of both human and physical nature, including technological, cultural and economic changes as well as physical processes such as climate change. These general trends indicate how the Southwest delta evolves not through the interactions between its layers and subsystems only, but also through its adaptation to a dynamic system environment: For example, current base layer challenges cannot be understood without considering climate change, and the infrastructure layer was crucially influenced by the industrial revolution and global trade (Cf. Dammers et al., 2014). Because of these transformative trends in its system environment, the Southwest Delta can be considered a complex *adaptive* system. And as these adaptations are not necessarily desirable, delta actors devise plans and spatial concepts for purposive intervention.

The above conceptualization thus articulates the apparent CAS properties of the Southwest Delta in a way that expresses both physical-spatial and social-governance complexity. Through this conceptualization we can also reformulate the above challenge of 'integrative' concepts: The integration of spatial functions and the synchronization between actors are to be understood as ways to respond to delta complexity.

3. Actor Analysis in a CAS Approach: Building The Method of Intersections Analysis

The search for integrative concepts can be supported through an understanding that accounts for Southwest Delta complexity. Arguably, the layered systems model (figure 2) can inform the search for spatial synergies, usefully distinguishing spatial processes and also articulating the associated governance complexity. In the following we outline our method of intersections: First, it is positioned as a method for disclosing system diversity

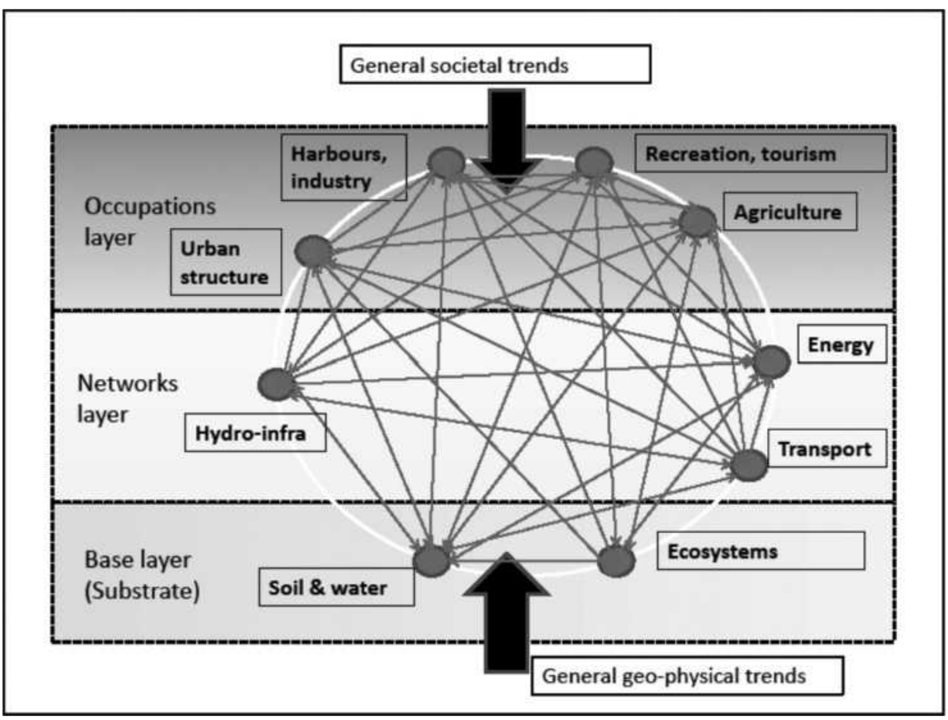

Figure 2. Southwest Delta as a Complex Adaptive System

(3.1). Next, we describe how this involves a stepwise combination of stakeholder analysis techniques (3.2) and subsequent classification and synthesis of these data into systemic 'configurations' (3.3).

3.1. Intersections Analysis: Disclosing Delta System Diversity

Considering the Southwest Delta as a complex adaptive system and seeking to develop accordingly complexity-sensitive spatial concepts, it is imperative to gain understanding of the relations between its subsystems (i.e. the arrows in figure 2). The latter 'intersections' indicate the subsystem interactions that are so crucial for CAS development (Holland, 1995). Still, CAS conceptualizations of the social world should account for the fact that this generally involves interactions between essentially diverse system 'components'. Due to this diversity, CAS conceptualizations should not be deceiving us into believing that some 'hidden order' can be relied on for policy advice - rather, it should sensitize us to the idea that interacting system components give rise to alternative trajectories (Byrne, 2005). We follow Byrne's plea for a non-reductionist understanding of emergence, considering that the reduction or articulation of diversity has profound implications for policy advice, and for spatial design.

Our method of intersections analysis is likewise informed by the 'transformative diversity' stressed by Stirling (2011). This notion captures his critique on the prevailing reductionism in transitions studies (Grin et al., 2010), a CAS-based approach to sustainability governance. Transitions studies is focused on structural, long-term transformations in societal systems, seeking to uncover the system feedback patterns that can account for these system shifts (see also Scheffer, 2009). Its normative orientation towards sustainable development tends to invite a certain preoccupation with particular system transitions however, and with particular directions for change – which do not necessarily reflect the system understandings of the actors involved. Instead, Stirling (2011) argued convincingly, it is crucial to observe the multiple transformations that take place in a system, the different normative directions they take, and the different ambitions, perceptions and resources of the actors who shape these transformations. Other transitions scholars have argued similarly for more fine-grained approaches that are sensitive to competing programs for change (Hodson & Marvin, 2010), intertwined decision-making arenas (Jørgensen, 2012; Späth & Rohracher, 2010), and different scales and areas of transformation (Raven, Schot, & Berkhout, 2012; Coenen & Truffer, 2012).

In line with these calls to respect transformative diversity, we seek to develop a fine-grained understanding of the delta subsystems' intersections. The delta system model should not become a reductionist straightjacket. It should rather serve as a heuristic through which to grasp the heterogeneity of the Southwest Delta system, and the diversity of its governance constellation in particular. This means concretely that the intersections between subsystems are not reduced into abstract 'mechanisms' of co-evolution, but rather as processes that are essentially constituted by the idiosyncrasies and interactions of *situated actors*. Likewise, in line with Walby (2007) and Jørgensen (2012), we treat our subsystems as strongly intertwined 'arenas of development', in which these situated and more and less well-positioned actors negotiate programs for action. The systems model, with its graphical suggestion of closed and monolithic subsystems (Allen, 2011), is thus brought into accordance with the ontology of ill-bounded and overlapping governance *networks* (Law, 1992; Kingdon, 1995; Kickert, Klijn, & Koppenjan, 1997; Koppenjan & Klijn, 2004). The earlier differentiation within layers is thus taken a step further, also differentiating within subsystems.

Finally, our fine-grained type of analysis should not completely forego the advantages of aggregation. However intricate and complex the processes at the delta system intersections may be, the 9 subsystems distinguished yield a multitude of those intersections. And as the analysis of intersections should ultimately inform spatial concepts that integrate, the disclosure of delta diversity should be followed by some sort of condensation. To guide such synthesis we can rely on existing classifications of interaction modes. A well-known distinction from game theory is the one between cooperation and defection, for example. This basic distinction resurfaces in classifications of co-evolution mechanisms: Sandén and Hillman (2011) (see also Odum & Barrett, 1985) distinguish between symbiosis, neutralism and competition, for example, thus adding neutral interactions. Furthermore they also distinguish *as*ymmetrical interactions (amensalism, commensalism and parasitism), which helps articulate issues of dominance. Yet it remains important for our purposes to realize that interaction modes may combine, change over time or remain uncertain (Axelrod, 2006; Sandén & Hillman, 2011; Pel, 2014). Moreover, the formal elegance of these classifications should not obscure the games real actors play (Scharpf, 1997). We therefore stick to the basic differentiation between 'interfering' (competing), and 'symbiotic' (mutually reinforcing) subsystems, keeping the scope for refined applications in mind.

Having outlined how we seek to disclose system diversity, figure 3 displays how intersections analysis zooms in on our systems model:

The delta's subsystems are broken down into checkered, diverse networks of actors. As will be discussed in more detail in the next subsection, these actors uphold different system understandings. This internal diversity of subsystems implies that their intersections can be observed in similarly differentiated fashion: Within the subsystem 'agriculture', for example, we find both established actors associated with current modes of production and upcoming innovators, and within the 'ecosystems' subsystem we find both advocates of nature conservation and champions of rather dynamic environmental management: Mainstream actors of subsystem 1 may then uphold symbiotic relationships with innovative strands in subsystem 2, whilst experiencing interference with its mainstream actors. Combined land-use between agriculture and ecological functions, to name a traditionally contested intersection, can thus be analyzed as an ambiguous *cluster* of interactions, shaped by the diversity of system understandings present in the subsystems involved.

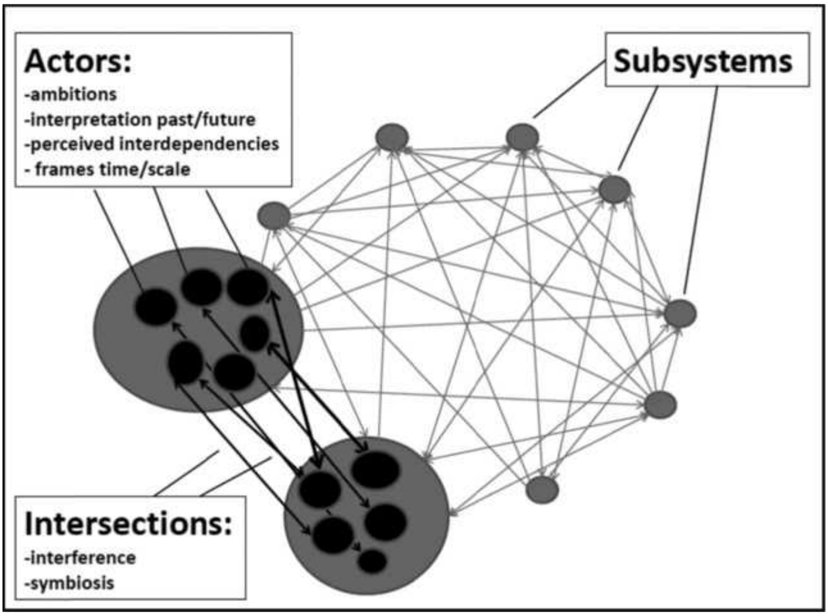

Figure 3. Intersections

3.2. Inventory: Systems-Oriented Stakeholder Analysis

Arguably, the concept of intersections brings CAS-thinking into closer correspondence with the synchronization challenges signaled upfront: It grounds these subsystem interactions in the interactions between situated actors. These situated actors are likely to diverge in their system understandings, identifying different systems, problems and solutions through their particular 'boundary judgments' (Ulrich, 1983; Luhmann, 1995; van Meerkerk et al., 2013).

An important first step in the intersection analysis is therefore to gain insight in actors' understandings of the delta system, and their position within it. Their system understandings, as diverse angles on the delta system, are reconstructed on four key dimensions (see figure 3): Their ambitions, their identification of relevant past and future developments, their perceived interdependencies with other actors (i.e. their shared aspirations, their recurring interferences with others) and their framings of time and scale. In this first step of stock-taking, intersections analysis thus amounts to a kind of stakeholder analysis. Stakeholder analysis methods have been developed in conflict resolution (Susskind & Cruikshank, 1987), project management (Edelenbos & Klijn, 2009), business administration (Ackoff, 1974; Mitroff, 1983), management studies (Savage, Nix, Whitehead, & Blair, 1991; Mitchell, Agle, & Wood, 1997) and public administration (De Bruin, ten Heuvelhof, & in 't Veld, 1998; Edelenbos, 2000; Koppenjan & Klijn, 2004). Conventional stakeholder analysis can be considered the process of identifying the individuals or groups that are likely to be affected by a proposed action, and sorting them according to their impact on the action and the impact the action will have on them (Ackoff, 1974). This information is used to assess how the interests of those stakeholders should be addressed. Stakeholder analysis is nowadays treated as key part of stakeholder management (Edelenbos, 2000) and network management (Koppenjan & Klijn, 2004). In this development, stakeholder analysis has evolved beyond the identification of key interests and values, but also includes analysis of network interdependencies and interactions.

Similar to these actor analyses, intersection analysis is aimed to reconstruct the main actors' perceptions of problems and solutions, as well as their network interactions and interdependencies. Yet instead of charting stakeholders in regard to a particular project or issue (Reed et al., 2009), intersections analysis uses the associated techniques of stakeholder interviews and document analysis to disclose the delta's diversity of system understandings.

This systems-oriented stakeholder analysis calls for some specific methodological measures, however. First of all, the time-consuming stakeholder interviews crucially require a selection of actors, representing the vast number of actors that tend to be present in delta systems. We have done so in line with our general orientation towards systemic diversity: We have selected actors who 1. are evenly distributed over the 9 subsystems distinguished; 2. occupy both dominant and subaltern positions within those, and 3. operate at different scales (local/regional/national/international). We have also distinguished between actors holding actual stakes, and experts. Arguably, these dimensions of diversity help to bring out the synchronization challenges that typically arise with regard to time, policy sector and scale (Edelenbos et al., 2013). As has been described more extensively in van Buuren, Pel, Verkerk, and Edelenbos (2014), this selection procedure resulted in 18 interviews, held in May-June 2012. The selection of documents to be analyzed was guided likewise by this diversity orientation.

Next to this issue of actor selection and system representation, a second methodological measure was to secure data gathering consistent with our research purposes. This is non-trivial, as our type of stakeholder analysis does not pertain to a specific issue, but is meant to disclose diversity. Data gathering was therefore structured by the four dimensions of system understandings distinguished earlier: Ambitions, interpretations of past events, perceptions of interdependencies, and frames of temporal and spatial scales. These dimensions formed the basis for an interview topic list, and also served as guideline for document analysis (see van Buuren et al., 2014).

Third, it was important to secure geographical concreteness, and stimulate respondents towards systems thinking. After all, our stakeholder analysis was not to serve policy advice on a particular governance issue, but should inform the development of integrative, complexity-sensitive spatial concepts. The reconstruction of interviewees' system understandings has therefore been facilitated by confronting them with our system's model (Figure 2) and a map of the delta area (Figure 1). This invited them to expose which subsystems they deemed relevant to their ambitions, and to mark present and future 'hotspot' locations where system developments manifest themselves. Moreover, the actors were asked to relate their main ambitions, projects, interferences and symbioses to the subsystems presented in the diagram. This helped us to chart the level and extent of divergence between system understandings, and to identify symbiotic and interferential subsystem interactions.

3.3. Condensing Variety: From Intersections to Configurations

After the above inventory through stakeholder analysis, the second step is to condense the uncovered variety into appropriate building blocks for spatial design. After initial emphasis on variation, intersections analysis crucially involves selection upon the bulk of intersections, and the identification of systemic configurations to play into with spatial design. This is a matter of stepwise narrowing down: First, the results from interviews and document analyses have been merged into pre-structured ‘factsheets’ on separate subsystems (van Buuren et al., 2014). Next, these factsheets were screened for salient intersections. This allowed us to establish a long-list of intersections, covering all nine subsystems.

This first condensation already yielded valuable insights: Our systems model comprises $9 \times 8 = 72$ intersections, discounting the interactions a subsystem may have with itself. Our empirical data brought out a clear difference between theory and practice: Some intersections recurred throughout the various accounts, whilst other subsystem interactions remained conspicuously absent. In other words, actors proved selective in their observation, focusing on some interdependencies and considering others as hardly relevant.

Having mapped the intersections long-list onto our system diagram, the subsystem relations most salient to the actors involved came out. As this subset still comprised a multitude of interactions however, further condensations was needed for subsequent identification of configurations. Such configuration, i.e. clusters of more than two subsystems that display interactions salient to actors involved, have been developed as follows: First, some of the intersections proved more prominent than others: The ‘hydro-infrastructure’ and ‘agriculture’ subsystems are notorious for their mutual interferences, for example. Gradually eliminating the relatively weaker intersections and lifting out the prominent ones, the crucial linkages in the Southwest Delta system became apparent. Second, the empirical data already provided useful indications of mutually connected intersections: In their accounts of the aforementioned ‘hydro-infrastructure’/‘agriculture’ intersection, for example, actors often mentioned the ‘ecosystems’ subsystem to be an integral part of the issue. Similarly, actors brought forward such clusters of intersections under general themes like urban development, economic growth, or sustainable development. Third, the condensation process was conducted in iterative fashion: The configurations were to be limited in number (3 to 5), yet together they should cover the 9 subsystems. Going back-and-forth between the early outlines of configurations and the intersections listed, our clustering into configurations could be refined.

Finally, it needs to be acknowledged that the above condensation process cannot be formalized exhaustively. The selection of salient intersections can be methodologically channeled, as described, but unavoidably contains an element of intuitive, creative synthesis. This may detract from the explanatory power of intersections analysis, and indeed there may be public administration frameworks that do better in this respect, but it also reminds of the particular purpose of our method: Intersections analysis is meant to inform the development of integrative spatial concepts, and thus gradually moves from analysis to design, and from science to 'craft' (Bertolini et al., 2012). A practical advantage is then that this method, or elements from it, can be easily deployed in participative fashion. This has been described elsewhere, in Pel, Duijn, Janssen, and Edelenbos (2013).

In the next section we briefly describe three configurations, as outcomes of intersections analysis. The nature and characteristics of these configurations differs; some configurations mainly indicate clusters of 'interference' to be overcome, others mainly indicate 'symbioses' to seize and to cultivate further. These configurations are starting points for design processes that take delta diversity into account.

4. Disclosing Delta Diversity: 3 Configurations

Intersections analysis charts the space for spatial concepts in tune with ever-dynamic governance networks. Our intersections analysis brought forward a couple of configurations that arguably capture the main bones of contestation in the Southwest Delta: These sets of intersections are described recurrently by respondents and also feature prominently in various policy documents and expert studies. We have labeled these configurations as follows: 'Settlement & employment' **(4.1)**, 'Living with nature' **(4.2)**, and 'Contested waters' **(4.3)**.

4.1. Disclosing Delta Diversity (I): 'Settlement and Employment'

The Southwest Delta is enclosed by the two major harbor-industrial complexes of Rotterdam (Netherlands) and Antwerp (Belgium) (see figure 1). More generally, it is a relatively sparsely populated area amidst the otherwise strongly urbanized areas of the Dutch 'rim city' conurbation and Flanders. Not surprisingly therefore, an important cluster of intersections could be identified and elaborated into a configuration on 'settlement and employment'. This cluster involves largely symbiotic intersections between the subsystems harbors & industries, transport, energy and urban structure.

The key ambitions involved are the enhancement of economic development on the one hand, and the safeguarding of attractive living conditions on the other. Interferences come up once economic growth is perceived to go at the expense of the environment, but several actors overcome these by arriving at common, symbiotic ambitions. The harbor-related industries around Vlissingen, for example, see their envisioned expansion of activities curbed by citizens' attempts to prevent the concomitant disturbance to living conditions. The industries and the housing corporation have therefore jointly initiated a project to improve the isolation of these houses.

As regards the identification of relevant past and future developments, most actors acknowledge this configuration to have resulted from a historic development path towards a 'red circle' around a 'blue-green heart'. The first is densely populated, with all kind of large-scale economic activities and facilities. The second exists of predominantly rural islands and regional water-related economic activities. Especially the actors from the urbanized rim around the delta seek to develop this blue-green heart primarily as an attractive residential area, thus serving the economic development of the delta area at large. This perspective interferes with local ambitions towards economic development, however. Especially harbor-industrial development and the associated transport investments should not be dedicated to the existing 'mainports' only. Local actors are suspicious about plans that mainly 'exploit' their area, for the resulting spatial-economic unevenness. Whether endorsed or not however, actors agree that this structure will continue to dominate delta evolution: In this regard harbor-industrial and transport subsystems are widely considered to be leading; actors from these subsystems also tend to uphold broad and influential strategic outlooks, considering the delta's prospects in a long-term, international context.

4.2. Disclosing Delta Diversity (II): 'Living with Nature'

The second configuration pertains directly to the delta's characteristic natural processes. It involves the ever-tense intersections between subsystems that rely on natural processes for their production, and the substrate-related subsystems themselves: The configuration thus comprises agriculture, ecosystems, soil & water, and water construction works.

As regards ambitions, the configuration can be considered ridden with interferences between economical ambitions, and concerns for the integrity of the substrate. To a considerable extent actors have found ways to overcome those: Farmers, for instance, engage in explorations of alternative ground water arrangements, together with groundwater officials and construction firms. Yet the robustness of the natural system remains an important ambition that often interferes with established rights and claims to eco-services. Farmers may find symbiosis with environmental conservation by allowing nature development at the edges of their land, which actually renders their production systems less vulnerable to insects. The scope for such symbiosis only goes so far however. Strong environmentalist pleas for a restoration of estuarine dynamics run up against an agricultural lobby that stresses the negative consequences for a freshwater supply that has been in place for several decades. More generally, this configuration is firmly rooted in the delta's historical development: With its alluvial and reclaimed land, and the combination of fresh river water and saline sea water, the area has fairly unique geo-physical characteristics that are of importance for agriculture, ecosystems, water construction works and soil & water. Actors in favor of ecological preservation consider the large-scale engineering interventions of the last decades as threats to the robustness and quality of the geo-physical and ecological processes. Their reference to historical qualities implying that these be restored, their assessment of past development has direct consequences for future developments. As this reading of history is not generally shared however, interferential relationships arise. With regard to future developments, two distinct strands can be noticed throughout these involved subsystems. Against the actors favoring all kinds of engineering measures to control and exploit the natural processes, there are actors who primarily seek to maintain ecological integrity, only allowing for mildly interferential exploitation.

The 'Living with nature' configuration is intriguing for its complex actor configuration. In the first place, involved actors display mainly diverging frames of time and scale: In agriculture, actors tend to focus on the local level, and their planning horizon is strongly based on the 7-year harvest cycle. By contrast, actors in 'hydro-infrastructures' are focused on nationally organized flood protection, and their investments in construction works entail planning horizons up to fifty or hundred years. Opportunities for symbioses arise when these different frames in time and scale synchronize nevertheless, for example when the use of agricultural land for dike reinforcement is combined with arrangements for land reallocation. Second, there is the fundamental difference between conservational and developmental attitudes: Actors in the ecosystems and soil & water subsystems are focused on protecting specific ecological qualities, and rely strongly on the associated regulatory frameworks. This leads to interferences, as actors from other subsystems are constrained. The very juridical approach tends to invite zero-sum framings of the intersections at hand, doing little towards the creative resolution of interferences. Finally, it is striking how the delta's actor constellation remains at odds with the functional logic of the layers' model: Whereas this model highlights the foundational importance (and political priority) of the substrate, it seems that the associated actors remain fairly weakly positioned vis-à-vis other subsystems. A further complication here is that 'soil & water' and 'ecosystems' are governed by hardly overlapping actor constellations.

4.3. Disclosing Delta Diversity (III): Contested Waters

The third configuration concerns a cluster of intersections most specific to delta areas, namely those related to their marine and fluvial waters. It is characterized by its multitude of interferences, i.e. the conflicts of interests emerging around different uses of these waters. The configuration mainly involves actors from the subsystems transport, agriculture & fishery, recreation and ecosystems, and primarily those who are directly related to the water (shipping, fishery, water recreation, wet nature).

Even when surrounded with interferences, this configuration offers ample opportunities for the development of integrative spatial concepts. Actors' ambitions are not interferential by themselves, but mainly arise from competing demands on scarce water surface. The delta's basins are needed for expansion or intensification of shipping and for similar growth ambitions in fishery and water recreation, whilst 'ecosystems' actors rather seek to protect some parts of the water. Altogether these spatial claims surpass the water surface available, which leads to interferences: The increasing number of sailboats causes not only more damage to the fishery installations, but also leads to frictions between recreational sailboats and inland navigation ships. It is interesting to observe how actors contextualize these interferences within a historical interpretation that is widely shared: All of these competing activities are acknowledged to have been economically crucial for a very long time. Their coexistence is seen to have become problematic over (approximately) the last twenty years only, however, due to European Commission directives on natural protection that decreased the (commercially) available water surface.

As they develop relatively autonomously, the interdependencies between the transport, ecosystems, recreation and fisheries subsystems are in general not very strong. Interferences tend to arise around specific waters or specific issues, however: Nature conservation organizations seek to foreclose economic activities around ecological valuable sandbanks for example, and this yields conflicts with the many fishermen who engage in mussels cultures. The place-specific nature of these interferences is reinforced by the generally regional or local orientation of involved actors. Moreover, apart from these local-regional orientations, most actors involved in this configuration are focused on the short or midterm. As these time frames tend to be based upon the continuation of the economic activities, interferences are not easily resolved: Concessions in this struggle over water resources have fairly immediate financial repercussions. The prevailing frames of time and scale thus seem to exacerbate the interferences between competing water uses.

5. Conclusion and Discussion of Findings

As introduced, the difficulty of synchronizing diverse programs of action and underlying system understandings creates a need for integrative spatial concepts. CAS-based thinking seems helpful for such integration – primarily when it is deployed to articulate systemic diversity. Intersections analysis approaches subsystem interactions in fine-grained fashion, appreciating that the co-evolution between subsystems relies on the intertwinement of actor networks and ultimately on the system understandings of actors. Yet it remains a methodological challenge to make the complexity-based understanding operative and productive. The merits of intersections analysis will therefore be evaluated through its results, i.e. its intended inputs for the development of complexity-sensitive spatial concepts. Comparing the three configurations, the following conclusions can be drawn:

1. All of the configurations can be observed to display *mixtures of interaction modes*. Notwithstanding the circumstance that some configurations can be typified as mainly symbiotic or interferential, none of them exhibits these co-evolution types exclusively. Interaction modes are likely to coincide or blend with others – and not seldom can they be turned into their flipside: Interferences can be overcome through creative solutions, symbioses may collapse under increasing scarcity, or under involved actors' zero-sum framings of subsystem interactions.
2. Second, it is striking how symbioses and interferences tend to be *momentary and location-specific*. The delta's various water-based activities only interfere at particular places, and the symbioses of the 'Living with nature' configuration can equally be

considered as only temporary 'windows of opportunity' within an otherwise rather interferential actor constellation. For the development of spatial concepts this holds the reminder that tailored designs are called for – also involving geographical specification of what has been inferred along systems-theoretical lines.

3. Third, all three configurations display issues of *distributive justice*. This is most apparent in the 'Settlement & employment' configuration, in which the emerged juxtaposition of 'red circle' vs. 'blue-green heart' structures creates cleavages between local development ambitions and supra-local visions that seek to curb those in the service of balanced development at a higher systems level (compare van Assche Duineveld, Beunen, & Teampau, 2011). The other two configurations display similarly difficult issues of distributive justice, manifesting especially in the tensions between local economic development, and overall protection of ecological values. These issues pose a caveat to spatial design: Spatial concepts better be developed with due consideration of the ways to negotiate the attendant financial aspects.
4. Fourth and finally, the *historical dimension* proves most relevant to the configurations developed. Many interferences are rooted in actors' diverging interpretations of past developments: These give rise to expectations and established rights, but are also invoked for the preservation of ecological values. Furthermore, some actors seem to take the emerged spatial-economic distribution as a guideline for further developments, whereas others rather seek to mitigate interregional unevenness. Finally, the nationally organized flood protection can be considered to result directly from the 1953 flooding catastrophe, which remains present in the minds of delta inhabitants. These diverging readings of history do not warrant resignation into path dependencies, however. Rather, they suggest that spatial concepts should somehow address historically evolved tensions, and express what systemic trends they seek to reinforce or mitigate.

The above observations show more concretely how CAS-based thinking, combined with techniques from stakeholder analysis, can inform the development of complexity-sensitive spatial concepts. Systemic configurations, and the intersections they consist of, are shown to be dynamic and contested, and each of the four observations provides guidance for spatial design. Intersections analysis can thus be said to put transformative diversity and geographical concreteness (Stirling, 2011; Coenen & Truffer, 2012) into practice: The three configurations elude further condensation into singular transition pathways, but constitute rather irreducible subsystem clusters that account for parts of overall delta evolution. More specifically, even the brief descriptions of the developed configurations reflect attentiveness to situated agency in complex systems (Teisman et al., 2009; Jørgensen, 2012). Arguably, intersections analysis is well-equipped to address the synchronization challenges (Edelenbos et al., 2013) through spatial concepts: Intersections analysis articulates actors' different outlooks in terms of time, sector and scale, as foundational inputs to spatial concepts that ultimately are to be carried by such diverse actor constellations. Highlighting actors' either developmental or conservational attitudes, for example, it also brings out how some seek to foster desirable system transitions, whilst others rather anticipate undesirable ones. The attention to this basic distinction meets Smith and Stirling (2010), who consider it a neglected issue in transitions research.

Notwithstanding these merits, there remains considerable scope for methodological improvement in intersections analysis. First of all, the aim for rich and dynamic representation of subsystem interactions is compromised in the process of converging onto configurations. One way to secure sufficient detail could be to apply a more rigorous differentiation within the interference/symbiosis distinction, such as the 6-fold categorization of Sandén and Hillman (2011). Second, the observed momentary and place-specific character of interferences and symbioses can be taken to warrant greater geographical concreteness. Of course, such pursuit of detail may be difficult to combine with analysis on the level of the delta as a whole. Still, this issue of comprehensiveness versus detail could be accommodated by inserting targeted analyses of particular systemic 'hotspots', as methodological complements (Cf. Broesi et al., 2013). Third, the identification of systemic configurations needs to be distinguished from the actual development of spatial concepts. Intersections analysis, however dynamic in outlook, theorizes mainly what under current actor constellations is possible, whilst paying less attention to what may be desirable under future circumstances. This reflects its grounding in present-oriented stakeholder methodologies. Also in this respect it deserves to be explored how spatial design, with its typically creative and counterfactual thinking, could function as a complement. More generally, this point indicates the importance of inserting other perspectives into intersections analysis. We have used elements of the method in a participative design process, for example, engaging stakeholders in our CAS-based approach to spatial design (Cf. Pel et al., 2013). Apart from its benefits in terms of societal relevance, this process also allowed for practical testing and fine-tuning of the method.

To conclude, intersections analysis has definite merits as a complexity-based methodology for the development of integrative spatial concepts, yet it leaves ample scope for further refinements. The shortcomings discussed, such as the tension between comprehensiveness and requisite detail, need not be taken to disqualify the approach altogether: The decomposition of complex systems is unavoidably accompanied with such methodological trade-offs (Luhmann, 1995; Cilliers, 2005; Carpenter, Folke, Scheffer, & Westley, 2009). The signaled merits and shortcomings are therefore of greatest methodological value when balanced in the light of specific aims, and when used to arrive at tailored solutions.

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