Chapter 8 Coevolution: a constant in non-linearity

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8.1 Introduction

Imagine being the Hamburg official quoted in the introduction to Chapter 5. It becomes obvious that the occurrence of change events is disruptive to policy processes. Events such as sediment accumulation disrupted the original plans in Hamburg and prevented the straightforward implementation of the next deepening operation. This was a clear setback from the perspective of the port authorities. The important question is whether or not this occurrence could have been avoided. The argument presented in Chapter 5 is that the occurrence of change events is inevitable and that disruptions to the policy process will continue to occur regardless of the efforts made to control it. However, understanding the occurrence and nature of unforeseen and sometimes unfavourable events could shed some light on the sources of disruptions to the policy process.

This chapter attempts to open that black box by substituting the anthropocentric perspective, where the decision maker is in complete control, for the coevolutionary perspective, which shows that change is often the result of coevolving systems, well outside the direct control of decision makers. We return to the Hamburg case and also look at another similar case, the management and development of the Westerschelde estuary in Belgium and the Netherlands, in order to demonstrate how a coevolutionary understanding of system change can enhance our understanding of unintended, unforeseen and sometimes unfavourable change.

The concept of coevolution is often used in complexity theory. Its use varies from a generic understanding of mutual influence between systems (cf. Mitleton-Kelly, 2003) to understanding the patterns of selection pressures and reciprocal selection (cf. Norgaard, 1984; Gerrits, 2008). This chapter takes coevolution to mean reciprocal selection between systems, a process during which future states of systems are selected reciprocally by other systems. As systems are nested, coevolution is not restricted to one level, but following the discussions in Chapters 1, 6 and 7, the concept of self-organization is much more apt in understanding the behaviour of individuals and groups. Coevolution surpasses that level.

In order to answer the question of what drives change, the process as well as the patterns driving that process longitudinally must be analyzed. Feedback is the core process between elements and systems. It is through feedback that systems continue to develop in the quest for a better fit with their environment. Continuous dynamic analysis, as per the discussion in

Chapter 3, should cover the feedback loops and the punctuated equilibriums resulting from feedback. A constant process of coevolution is noticeable between (nested) systems.

A conceptualization of coevolution is presented in the next section. Section 8.3 utilizes the conceptualized elements and mechanisms of coevolution to analyze the cases of the Westerschelde and Unterelbe estuaries, which are perfect examples of how social and physical systems coevolve from one temporal state to another. How patterns and concepts of coevolution can be used for an analysis of public policy processes as well as how it may be used as a guiding principle for public managers is the subject of the next chapter (Chapter 9), authored by Van Buuren, Gerrits and Marks.

8.2 Conceptualizing coevolution

Evolution is the change of elements – species, systems, actors, technologies – across a certain time span. Elements change because they have an incentive to do so, when they are under certain pressures. The social phenomena under investigation in this book are connected with other social phenomena. Elements may adapt themselves to new situations, but other connected elements may adapt as well. In other words, systems are not evolving in an isolated environment; their environment evolves as well, and this environment consists of other systems and actors within these systems. Evolution is thus not a unilateral cause-effect relation, but a mutual process between all elements in a particular case. According to Mulder and Van den Bergh (1999), all evolution is in fact coevolution as soon as there are two elements influencing each other. Thus, when we talk about the change of things in the social world, we talk about coevolution: the ongoing process of mutual adjustment between interconnected elements. Mutual adjustment is not a generic term, it consists of patterns of reciprocal selection. This is explained further in the following sections.

8.2.1 Systems not at rest

Systems coevolve with other systems over time. That is, there is a continuous process of mutual adjustment since the high variety of systems cause them to constantly adapt to new situations. Contrary to the assumptions made in first generation systems theory, systems never achieve an optimal or definitive equilibrium. One way to understand this is by looking at the development of economic systems. Evolutionary economics centres on the observation of temporal equilibriums rather than permanent equilibriums. Apparently, there are numerous equilibriums and systems appear to jump from one stable state to another. In the vocabulary of evolutionary theories, such states are called attractors. The group of attractors describing all

possible future states of a system form a phase space (Gleick, 1987), a state space (Kauffman, 1993) or an attractor basin (Arthur and Durlauf, 1997; Martin and Sunley, 2006). Thus, systems are located in attractors and have a number of possible next states available, termed the attractor basin (see also Gerrits, 2008).

From an evolutionary economics perspective, economic systems contain large numbers of heterogeneous agents interacting simultaneously that drive economic change through its heterogeneity. The interaction between economic agents takes the form of competition and cooperation. Competition structures economic activity and selects the best fit outcome, e.g. the best organizational arrangements. These selection processes destroy and create variety, which is the driving force of change in (economic) systems (Foster and Hölzl 2004: 3-4). Although systems can achieve balanced states, these states are temporal at best, if they are ever reached.

8.2.2 Coevolving social and physical systems

The notion of coevolution stems from biology. Norgaard (1984; 1994; 1995) developed the idea to apply this biological notion to the interaction between physical systems and social systems. He reflected on the idea of progress as a linear trajectory towards a certain goal and concluded that this perspective does not do justice to the complexity of social and physical reality. More specifically, whereas modernism regards the relationship between these two types of systems as hierarchical, Norgaard deems this relationship to be mutual and reciprocal or of a coevolutionary nature.

Development constitutes an ongoing struggle through the attractor basin towards an uncertain future where the next attractor is the result of the interactions between social and physical systems rather than the result of an action by one particular actor or systems. Coevolution is not a process that can be controlled. Systems develop and actors are dragged along, although they have the potential to generate some influence through their actions that cast selection pressures on elements to change. However, to control the process is an entirely different matter, even if such ambitions exist.

As argued in Chapter 4 and 5, systems develop in a non-linear manner that actors experience as erratic and unpredictable. Systems coevolve without one system constantly steering the other. Norgaard therefore shows that the idea of coevolution has considerable consequences for an understanding of system dynamics.

8.2.3 Nested systems and boundary judgments

Not only are systems and their (horizontal) interactions complex in and of themselves, but they are also part of a larger complex system and comprise of smaller systems within themselves (Byrne, 2005) Interrelatedness and feedback occur both horizontally and vertically as well as within and between all the (nested) systems. All these levels of interaction have the potential to influence one another. As argued in Chapters 1, 3 and 7, system boundaries do not exist a priori. What constitutes a system is a matter of judgment by the actors compromising the system as well as by observers. This means that depending on what one wants to know, the systems and their boundaries are defined by the analytical questions of the observers. In other words, boundaries and systems are not given, but dependent on the focus of attention: the system and its boundaries in one scenario may be nested systems in another, or vice versa. The 'policy system', a term that will be explained and adopted later in this chapter, is therefore not an entity that exists outside actors' interpretation but an account of the actors interviewed in this chapter.

8.2.4 Adoption, adaptation and types of coevolution

In the vocabulary of complexity theory, the basic elements of systems are known as agents. In the domain of public administration, however, describing these elements using such a generic term is insufficient. Agents can be individuals but they can also be (nested) systems, e.g. organizations, departments, ports and rivers. A distinction can be made between active entities and passive entities. Actors are active entities: they exhibit adaptive behaviour and are able to adapt themselves to changing environments. Agents are passive: they exhibit adoptive behaviour, because they process information but do not actively seek to fit within the system. Agents and actors make up a system, but that system itself can be an adaptive agent among others in a bigger system, which in turn may be another adaptive agent in an even bigger system (cf. Holland, 1995).

Odum (1971) has developed a categorization of mutual interactions depending on the type of result for the systems involved. His classification also takes into account the size of the population, which allows for a distinction between the predator and the prey, or the parasite and the host. Since it is argued here that systems are essentially social constructs and that their size is therefore variable, it is not possible to replicate this in the context of social systems. However, his classification provides a starting point from which to understand the behavior of agents and actors alike in coevolution and the consequent results of their behavior. This in turn can help practitioners to understand which pattern of behavior could promote a certain

type of coevolution, allowing them to reconsider their strategies from a coevolutionary perspective.

In cases where the state of all systems alters to a state that constitutes degeneration for all concerned, this type of coevolution is categorized as *interferential*. This can occur when actors attempt to adapt or adopt using what they deem to be the best strategy that could actually mean a worsening. Collaborative policy processes may sometimes exhibit this type of coevolution: actors try to find a compromise that is acceptable to all, but the overall result does not match the actors' expectations. The 'tragedy of the commons' is another example.

However, when agents manage to position themselves in such a way that their system evolves into a favorable state at the expense of other systems, this type of coevolution is characterized as *parasitism*. Due to power differences, this type of coevolution can be easily seen in many adversarial policy processes. In cases where the adaptation or adoption means a progression towards a more favorable state than before as perceived by all the actors involved, this coevolution can be characterized as *symbiotic*: the coevolution leads to results that do not come at the expense of anyone or anything. It should be noted that not all interaction leads to changes in systems and therefore to coevolution, or that coevolution can take place through interrelatedness (unintended or intended) or combinations of interactions and interrelatedness.

Actors as agents look for appropriate ways of acting and responding in complex environments. What is appropriate and why would actors want to act accordingly? Assuming that actors want their intended effects to be realized, they are required to define a desired future state, assess the current situation and attempt to undertake the actions that they consider to serve the end. Since other actors act and react as well, and at the same time, obtaining the right effect is not an easy task – the environment of an actor moves on at the same time that an intention is executed. Simply put, the better an actor can obtain its desired effect in that moving constellation, the better its fit.

8.2.5 Shaping the process of coevolution

The process of coevolution is shaped by a number of developments: feedback, attractors, punctuated equilibrium and reciprocal selection. *Feedback* is considered to be the driving force in and between coevolving systems. Feedback in systems is the return of a portion of the output of a process or system to a certain input. Feedback is a process surging both horizontally and vertically through the networks and can have different types of impact (Norgaard, 1994). Actors and systems attempt to adjust to the new situation, in which they work to achieve their goal. Since every actor or system attempts to do this, the situation

around them is constantly changing. Systems and actors do attempt to adjust to this constant change and do find temporal equilibriums. As mentioned before, these *attractors* are the situations –desired or undesired– that are temporally hard to escape because of feedback surging through the systems. Definite stable equilibriums do not exist, and dynamics create systems that attempt to achieve new equilibrium states because of the changed conditions and pressures: i.e. *punctuated equilibrium*.

The basic idea of punctuated equilibriums is that there are a number of possible states in which a system can rest, as it were, for a limited amount of time: the attractor basin. Systems, then, go through periods when everything is seemingly at ease, albeit not stable, as well as periods of severe fluctuation in the process of changing from one attractor to another. Punctuated equilibrium is essentially about the changes in the velocity of changes: more changes take place in some moments than in others. Coevolutionary changes do not stem from the moment the change is perceived but rather from the build-up of pressure during periods of relative stability. Once a system has moved to a new attractor, it is difficult to undo that change (Van den Bergh and Gowdy, 2000).

The connection between all these elements can be depicted in the following figure, which is the representation of a theoretical attractor basin. Depending on the initial conditions (see Chapter 1), possible chance events that may occur (see Chapters 4 and 5) and the feedback surging through the system, the system undergoes pressure to move to a certain temporal stable equilibrium; that is, towards an attractor (w^i, x^i, y^i or z^i). Once the system reaches an attractor it can move out of it and towards another attractor, but the amount of energy required may be quite large because of the existing feedback pushing towards the existing equilibrium. However, because of the (constant) dynamics, the conditions, chance events and feedback may change and other new attractors may come into existence. In other words, on a longer time scale the cycle starts all over again and another basin exists in which the system may move to another attractor; i.e. punctuated equilibrium.

insert figure 8.1 near here

What is of importance here is the fact that, due to information constraints (see e.g. Simon, 1991), actors are only capable of observing a limited amount of the attractor basin. This view of the attractor basin can be altered by engaging in research and by connecting with actors that have alternative views. The part of the attractor basin that an actor can oversee is called the attractor basin. This is indicated by the solid lines in figure x, which demonstrates that a

given actor fails to observe attractor x. The actors make decisions based on the projected attractor basin. The consequences of the decision cast selection pressures on the systems. In order to clarify the process of coevolution empirically, two case studies will now be presented.

8.3 Unterelbe and Westerschelde

Empirical data for these case studies was gathered through interviews with 50 respondents, analysis of the relevant policy documents and analysis of over 300 newspaper articles published on these issues. See Gerrits (2008) for a more thorough and extensive study. In both the cases of the Elbe and the Westerschelde, several systems that are the units of analyses are interrelated: the natural or physical system of the estuary, the social system of interest groups, lobby groups, inhabitants and the policy system, which consists of the main policy actors related to the estuary (e.g. water managers, port authorities, etc.). As mentioned in the introduction, the boundary between the policy system and the social system is one constructed by the respondents. Thus, a policy system includes actors considered to be a part of the decision making process. Managing the estuary (to enable shipping, for example) means influencing the behaviour of this physical system and reacting properly to changes within this behaviour. Therefore coordination between the social system (economical, recreational and environmental interest groups) with its own interests, strategies and actions and the policy system is necessary to realize legitimate and effective collective action.

8.3.1 The Unterelbe

As mentioned in Chapter 4, the Unterelbe estuary and tidal river in Germany, the physical system in this case study, meanders from the North Sea at Cuxhaven to the port of Hamburg and provides maritime access to this port. It also features some natural elements that are important for (estuarine) ecology, such as shoals, sandbars and floodplains.

Because the port authorities want to keep their port accessible to the largest ships and because the ever-changing morphology and relative shallowness of the Unterelbe can hinder shipping, the authorities want to dredge the waterway for maintenance and occasionally deepen the main navigation channel. The most recent deepening of the Unterelbe was finalized in December 1999. Since then a monitoring program has been initiated in order to follow the consequences of the deepening. The port authorities have been preparing a new deepening operation since 2002, to be completed in 2008.

The policy system consists of the main policy actors who cooperate in order to facilitate the further modification of the Unterelbe. Because of the way in which the Free Hanseatic City of Hamburg is organized – with the federal state and the municipality converging – these policy actors routinely work together. There are a number of research institutes affiliated with this policy system.

The Unterelbe flows through two other federal states – Niedersachsen and Schleswig-Holstein - before discharging into the North Sea. Although these states and their constituent municipalities are policy actors in the strict sense of the term and even have some authority over the Unterelbe, they are not included in the policy system of the City of Hamburg. The reason for this is that they do not share the eagerness of Hamburg to deepen the Unterelbe. They fear an increased risk of flooding and environmental damage and are also searching out ways to develop ports within their own territory. As such, their stance alternates between cooperation and obstruction.

A number of actors who are a part of the stakeholder environment of the Unterelbe are not included in the policy system and form the social system around it. These are the environmental pressure groups, the recreational shipping associations and the fishermen. The environmental pressure groups oppose further modification of the Unterelbe, because they fear that the environment is unable to cope with the strain. The fishermen and the recreational shipping associations fear that an increase in the number of cargo ships and the increase in their size limit the possibilities of their breadwinning activities or hobby. There are also complaints that the deepening leads to sedimentation of the small ports along the banks.

There is a clear distinction between the social and the policy system as the latter distinguishes itself by its singular mission: to deepen the Unterelbe, while this mission is controversial in the social system. These three systems generate selection pressures on one another These pressures are summarized in Table 8.1 and lead to several coevolutionary changes over time, which are discussed in the next section.

Insert table 8.1 near here

Operations to modify the Unterelbe, making it suitable for economical utilisation and protecting the people living behind the dykes go back to the beginning of the 20th century. This case study begins in 1996. While there was a rush to execute a deepening at that time, because the current depth of the Unterelbe was deemed insufficient, there are also a number of physical developments that require attention. First is the problem of handling dredged

material. There is continuous sediment accumulation that requires maintenance dredging operations. However, there is a lack of capacity to store or remediate the dredged material. The increasing tidal range is an issue at this stage as well. The increasing tidal range indicates a change in the relationship between ebb and flood in the tidal river and as such may indicate an unfavourable change with regard to sediment transportation. Any increase in sediment accumulation is considered a threat.

The two federal states of Niedersachsen and Schleswig-Holstein take an ambiguous stance toward the deepening. They agree with the argument that the region as a whole can take advantage of the further development of the port of Hamburg. At the same time, they oppose the deepening because they believe it compromises the safety of their dykes and fear that they may have to pay for environmental damage.

All pressures have a selection capacity on the process of managing and developing the Unterelbe. They mark the bandwidth between what is feasible and what is impossible. However, selection pressure is processed through the policy action system, which enables actors within the system to provide direction to the process by applying selection mechanisms.

Applying selection mechanisms (January 1996 – December 1999)

In order to obtain an idea of the future possibilities and to deduce the actions required to achieve the desired future, the policy makers use four selection patterns. Its response to pressures and its composition can be managed by managing the *connections* between actors within the system on the one hand and the actors within the environment on the other. With regard to the *composition* of the policy action system, the actors within the system appear to be inclined towards assimilating actors who are in favour of a deepening, whereas actors who oppose the deepening are kept at a distance. In order to understand how a deepening can be carried out with minimised unfavourable results, *research* needs to be carried out. Research is also imperative because such large projects require an environmental impact assessment. The *scope* of the project is set and clearly not changeable. The first and most important aim is an efficient deepening of the navigation channel in the Unterelbe. Complementary measures are only considered when they are required in order not to obstruct the primary goal. The decision to deepen has already been made and this is a point of no return for the policy action system. While the process of assessing objections may still be in full swing, policy makers do not await the outcomes and instead, begin right away under the banner of ‘preparatory dredging’.

The policy action system is caught in a vicious cycle during this phase. The diversion of alternative events and ideas that may disrupt the dominant way of thinking reinforces the belief that the right thing has been done. This in turn reinforces the dominant belief in the righteousness of deliberately diverting away selection pressures that may alter the dominant course of the system. Such a regime means that selection pressures no longer affect the policy action system, leading it to believe that it has done things in the correct way because there is no one to tell it that it has not. Consequently, the policy action system is confirmed and reconfirmed in its current way of acting. However, as the case shows, the pressures that could disturb the process are only diverted away, they are not dissolved nor processed in any way. Later, they become visible again and can no longer be neglected.

The projected attractor basin (January 1996 – December 1999)

In terms of our theoretical framework, the actors within the policy action system build a scenario for the desirable future state of the physical system, based on the selection pressures and the way in which policy makers deal with them. This consists of three parts: an image of the current state of the physical system, the desired state of that system and the measures that are required in order to achieve that state. In other words: it defines an image of the future attractor basin and from that projected basin it chooses a desired attractor of the physical system and the social environment, without fully knowing the actual attractor basin. The next chapter deals with the contents of policy processes aimed at creating a desired future in more detail.

What actors see is what they have, consciously or unconsciously, selected from the attractor basin, or what has been forced upon them through selection pressures. The attractors or future stable states of the Unterelbe as articulated by the policy action system therefore do not represent the full attractor basin but rather, the projected attractor basin, i.e. the part that is observed and understood. The main target for the future stable state of the Unterelbe is a deeper Unterelbe with little room for contextual development. There are some premature ideas about the management of the sediments and in the end, the planners settle for aquatic dispersion in the Unterelbe. There are also some ideas about compensation measures that are required to keep the Unterelbe in that future state. With regard to the social environment and its actors, the policy action system opts to serve the demanding parties such as shipping and trading companies exclusively and chooses not to address the concerns of those who oppose the deepening.

Consequences of selection and action (December 1999 – October 2004)

The selections made by the policy action system during the planning and execution of the deepening are not without their consequences. The accumulation of policy decisions exerts a continuous strain on the physical system that results in a change in the state of the physical system that partially fulfils the desires of the policy action system (a deeper Unterelbe), but that also brings with it a sudden increase in sediment accumulation and a changed tidal regime that may threaten the ambitions of the policy action system. The accelerating sediment accumulation in the harbour means that the port authorities have to double their dredging efforts – something that, given the lack of capacity to manage the dredged material, is very difficult and costly. Moreover, it comes with a change in the tidal range that leaves the city channels' riverbed exposed during periods of ebb.

The singular focus on the desired state of the Unterelbe (a deeper channel) also has an effect on the societal environment of the policy action system because the drive to have the Unterelbe deepened results in societal concerns not being addressed and instead, being diverted to the future. This is reinforced through the political change in the Hamburg senate. The unexpected change at the federal government level (from SPD to CDU) allows Hamburg to get its deepening but also reinforces social opposition. In other words, the selection pressure to continue the utilisation of the Unterelbe as an economic asset gains momentum through the political change but also regenerates the societal opposition against further modifications of the Unterelbe.

The actual attractor and its selection pressures (December 1999 – October 2004)

The difference between the projected attractor and the actual attractor of the physical and social systems results in pressures on the policy action system because it creates a situation that, far from the desired future, provides a future with considerable problems for policy makers. They are now obliged to deal with the physical changes and social opposition, both of which stem from their earlier decision but did not feature in their future plans. Singular decision making, in which the project is narrowed down to a single goal and in which the decision is made not to address certain issues, results in the diversion of these issues. They are diverted to the future, meaning that they return as selection pressures later on – they do not disappear. These pressures are part of the new attractors.

Societal resistance has also not diminished. Instead, the policy action system encounters increased resistance because of the way in which societal actors were treated during the earlier deepening operation. Finding a joint solution with the environmental pressure groups

becomes a more pressing concern when it is ruled that these groups are now entitled to file a complaint during the official planning process, a development from the situation during the previous planning procedure.

The new state of the physical system also raises concerns from societal actors as they perceive that the previous deepening has caused exactly what they feared it would cause: an increased tidal range, erosion of sandbars and beaches and with that, an increased risk of dyke collapse. The policy action system encounters this resistance during the years that follow and especially during the new planning process for the next deepening. It pressures policy makers to adopt a new strategy in order to deal with these public concerns, as a new round of deepening is not likely to be accepted by the public and by the neighbouring federal states.

It becomes clear that the policy action system has manoeuvred itself into a position in which its regime becomes increasingly challenged through the pressures it has attempted to divert away in the past years. The selections made by the policy action system appear to backfire on it in several ways, in both the physical and societal dimensions of developing the Unterelbe.

8.3.2 The Westerschelde

The Westerschelde estuary in the southwest of the Netherlands runs from the North Sea to the border with Belgium and the port of Antwerp. Like Hamburg, Antwerp is one of Europe's largest ports. The authorities at the Port of Antwerp aim to deepen the estuary in order to facilitate the movement of larger ships. The Westerschelde also features important natural areas and the dissipative character of the riverbed forms a threshold against floods. Because the estuary is located on Dutch territory, the authorities of Antwerp are required to obtain a Dutch permit for deepening operations. The most recent deepening took place between 1997 and 1998. This operation was the outcome of a long negotiation process that lasted almost 30 years. Final permission was provided after the Flemish authorities agreed with the construction of a high-speed railway link between Flanders and the Netherlands, thereby granting an old wish from the Dutch government.

The policy system consists of actors who are working on the management and development of the estuary. Unlike the Unterelbe case, these actors are not necessarily aiming at a deepening – the fact that the estuary falls under Dutch authority means that there is no dominant orientation towards deepening the estuary. The strong convergence of port authorities, authorities for managing waterways and research institutes as observed in Hamburg does not occur in the Westerschelde case. Still, it should be noted that there are strong ties between

actors within the policy system – especially between the Dutch governing authorities and the research institutes, but far less between the Flemish and the Dutch actors.

The social system consists of actors who are in any way opposed to the further development of the Westerschelde. The environmental pressure groups are very similar to those in Hamburg with regard to their objections and wishes: no increase in the utilization of the Westerschelde by cargo ships and a restoration of the old situation in which the estuary has more room to develop. The agricultural organizations are strongly against this and against further development, as they fear that this means the conversion of agricultural land into floodplains and hence increases the risk of more floods. The different systems and their pressures are summarized in Table 8.2.

Insert table 8.2 near here

The Flemish actors (Port authorities, City of Antwerp, the Flemish government), rather than the policy action system, lobby for a deepening of the Westerschelde. Consequently, the pressure to deepen the Westerschelde is not self-generated pressure from the perspective of the policy makers but rather selection pressure stemming from a specific group of actors from the societal environment.

There are a number of different pressures. The strongest one, and the one shared by actors in the policy action system such as Ministry of Public Works and Waterways and the local authorities in Zeeland, is not to give in to the desire to deepen. There are three categories of motives for opposing this. Firstly, there are actors who feel that a deepening will only benefit the port and city of Antwerp while the Dutch region would not receive anything. Secondly, there are actors who oppose deepening because of environmental concerns. Finally, there are actors who fear that a deepening of the estuary requires compensation for environmental damages. Such compensation would be at the expense of agricultural areas and probably also require the realignment of dykes, which is a very sensitive topic in the region because of the catastrophic flood of February 1953.

Physically, no immediate pressures are observed apart from a number of developments that may indicate a trend. Some researchers state that the eastern part of the Westerschelde is becoming increasingly rigid and that this harms the dynamic nature of the estuary and reduces its ecological value. However, this poses no immediate selection pressure on the policy action system. Once a deal regarding the link is put in place, agreement over the Westerschelde is forthcoming.

While the decision to deepen is nearing its conclusion, the pressure to broaden such an operation to include a more versatile development of the Westerschelde that includes nature restoration gains momentum. The policy action system must respond to these diverse pressures through the application of the selection mechanisms.

Applying selection mechanisms (July 1993 – May 1999)

The policy action system displays an ambiguous stance: it opposes an operation but at the same time realises that it is also reasonable to grant a deepening. Once the agreement is reached and the deepening has to be planned, the policy action system acts rather quickly.

The handling of *connections* by the policy action system is not single-sided as it alters its stance from rejecting a deepening to accepting it. In doing so, it alienates actors who oppose the deepening of the Westerschelde from the policy action system as the latter is no longer clearly blocking changes to the estuary. At the same time, the policy makers must cooperate with the Flemish actors in order to plan the deepening. This provides an incentive for the opposition to organise themselves within the Administrative Consultation Westerschelde (or BOWS) initiative in an attempt to counter the pressure to deepen. The policy action system attempts to avoid delays by constantly reducing the opportunities for the opposition to protest. Altogether, this means that the *composition* of the policy action system remains fairly stable. *Research* on the deepening of the Westerschelde is meant to facilitate the planning and execution of the operation. No alternative scenarios are investigated, nor does the research extend to adjacent areas. Knowledge of the developments within the physical system is available but at the same time rather fragmented between the actors in the policy action system. The *scope* of the project is narrowed down to a deepening and the obligatory compensation. However, since the pressure to get the operation done as quickly as possible remains the priority, compensation is not really thought through and at the time of planning there are only a few ideas on paper that are not very concrete.

The projected attractor basin (July 1993 – May 1999)

During the planning of the deepening, the policy action system formulates its goals for the future state of the estuary and, based on the current state of the Westerschelde, it also formulates the means to that end. In the vocabulary of the theoretical framework: it develops an image of the future attractor basin and from that chooses an attractor as the desired future stable state of the physical system and the societal environment, including the way to achieve

that state. As the selection pressures push the policy action system towards a deepening and as the system itself applies selection mechanisms, it defines a projected attractor basin.

Clearly, the main goal is the deepening of the Westerschelde and complementary measures are not considered for inclusion in the process except for the obligatory compensation. Although the damage incurred by the deepening operation is not defined as part of the future attractor, it remains a part of the attractor basin as it is investigated in the long run.

The policy action system accepts that the deepening will provoke resistance from a part of the societal environment whilst serving the part of society that requires the deepening, i.e. the Flemish actors. This leaves a number of actors dissatisfied but that is taken for granted and, if possible, is dealt with in a legal way. At the same time, it is acknowledged that those who oppose the deepening raise pertinent concerns that are shared in the policy action system. Again, these are diverted away for the time being, with the intention of being dealt with later. In any case, these concerns are known and acknowledged as being relevant and they are therefore part of the projected attractor basin.

Consequences of selection and action (May 1999 – December 2002)

The main consequence of the selections made and the actions carried out is a deeper Westerschelde as part of a singular project, i.e. a project with a narrow scope. The deeper Westerschelde does not appear to create unfavourable side effects, at least not at the time, so the operation constitutes a negative feedback loop, i.e. it achieves the expected (temporal) equilibrium. The constant rush for a more comprehensive development perspective for the Westerschelde leads to dissatisfaction within the policy action system. A working group is established that can be regarded as a response to the selection pressure to develop a more comprehensive plan before engaging in another deepening operation.

The point of departure is that further development of the estuary must be conducted within the sustainability framework. A project organization, ProSes, is created to develop a concrete plan in which a deepening is paired with ecological development while maintaining or improving the safety conditions along the estuary. Although the (singular) deepening of the Westerschelde has not yet sparked off any major physical changes, the singularity attracts the attention of the European Commission (EC). A narrow scope, limited research and relatively closed connections were supposed to safeguard the project from further delays but this now backfires on the policy action system as the EC decides to investigate the lack of compensation measures. The nature of the operation also triggers an investigation by the Court of Audit. Their main finding is that motives and means for the previous deepening were

not as sound as required by law. Observing that the policy action system is not very willing to facilitate another singular deepening after the previous operation is completed, the port authorities establish the Port of Antwerp Expert Team to counter the idea that further deepening of the Westerschelde is harmful and to prevent potential delays.

The actual attractor and its selection pressures (May 1999 – December 2002)

The operation leaves the Westerschelde deepened, which corresponds with the expectations of the projected attractor basin made by the policy action system. Although there are no immediate unfavourable physical changes, there are many actors who wish for a different type of development in the future. The first pressure from the current state of the estuary is therefore to search for a more comprehensive development of the Westerschelde. This is reconfirmed through a subsequent string of initiatives that pursue such a comprehensive development. Substandard physical compensation for the deepening attracts attention from the European Commission and the Courts of Audit. Their findings add to the pressure to adopt a more considerate approach towards the Westerschelde.

There are also pressures not to develop such an approach but these follow in response to this change in the stance of the policy action system rather than from the actual physical state. Similarly, societal unrest in Zeeland with regard to the possible consequences of compensation and nature development on the actual land-use, leads to pressure not to modify the Westerschelde at all.

The actual state of the physical system conforms to the intentions of the policy action system while, at the same time, there is doubt as to whether another operation will be desirable. The actual societal environment involves, as expected, the Flemish actors demanding a new round of deepening while the many actors in Zeeland province oppose any change. Together with the other pressures, this leads to a diffuse mix of pressures on the policy action system. Although there were no major unfavourable developments after the deepening, pressure continues to be put on the policy action system because of the dissatisfaction among many actors regarding the actual state of the estuary.

8.4 Conclusions

Coevolution between the policy system and the physical systems takes place, regardless of any ideas about its desirability or direction. Both cases show that policy systems have to and do respond to physical developments (Unterelbe) and even to the possibility of a physical development without that development actually taking place (Westerschelde) through a

redefinition of their systems' disposition and boundaries. Similarly, physical systems respond to policy systems by adapting to the newly-created situation, such as dredging operations or deepening operations. These adaptations lead to pressure from the social system because of its perceived undesirable effects. The policy system then responds to this again. In this way, a complex pattern of interrelatedness and interactions emerges between the three systems. The process of coevolution between and within the systems, i.e. mutual influence through selection and adaptation, does not occur in a linear and smooth fashion. The physical system shows that changes sometimes occur unexpectedly and sometimes not proportionally to the incentive. The policy system shows similar developments. It takes considerable system pressure for changes to take place, but once these changes do occur they can be far-reaching and become out of the control of the policy makers. This results in new but temporal and dynamic equilibriums. To put it more precisely, the process of selecting the future attractor is influenced by the dynamics of the physical system, social system and policy action system. There are six aspects of this.

Firstly, although the policy action system made intentional selections with regard to the desired future attractor of the physical system, it was also subjected to blind selection stemming from earlier decisions that led to adverse effects, accidents and events. The actual physical developments brought and kept the estuaries in an attractor that yielded unfavorable results or the threat that this could happen soon. Such was the situation that, in both cases, the policy action system had to respond to these problems – each in their own particular way. The attractor basin was limited not only by deliberate choice from the policy action system but above all by the actual physical developments – especially because the new stable states proved to be persistent.

Secondly, there is a non-linear relationship between the selections made by the policy action system and the consequent responses. Such responses did display a punctuated nature with changes taking place elsewhere in time. Therefore, the policy action system could face a new, unintended situation. Together with the complex causation between physical change and measures from the policy action system, this could render change unintended, unobserved and unexpected.

Thirdly, upon facing this uncertainty, the policy action systems responded to the selection pressures stemming from these situations by altering the selection mechanisms and with that, the disposition of the system. By and large, there are two types of responses, as argued in Chapters 6 and 7. The first type of response is characterized as autopoietic self-organization.

Such ‘singular’ policy action systems respond to selection pressures by connecting with those actors who support the goal of the policy action system and by shielding the process from those who oppose it. This results in a narrow scope of the project and consequently in research exclusively aimed at finding the means to that narrow predetermined end. In other words, the boundaries are redefined in such a way that it enables the system to cope with selection pressures through reinforcement of the internal coherence in an attempt to keep the project under control as it is deemed to be complex enough already without factors that are considered distracting.

However, such an approach can be become unacceptable if the selection pressures that were diverted backfire on the policy action system, forcing it to alter its regime. The second type of policy action system is characterized by a composite nature and is labeled dissipative self-organization by Pel in this book. Actors within this type of policy action system redefine their systems’ boundaries and enable it to connect with other actors in order to expand the variety of ideas and goals in the process. This results in a debate that questions the scope, subsequently taking into account more than one aspect of the physical system. Research is also aimed at exploring options rather than only finding the means to a given end. This classification is further explored in terms of managerial strategies in Chapter 11 on project and process management.

Fourthly, while the classification into singular and composite policy action systems may suggest a stable dichotomy, empirically it was observed that the composite characteristics are encapsulated in the singular policy action system but are not always unlocked. A more composite nature is also not the definite state of the policy action system as it can convert (back) into singularity. Change or consolidation of regime was induced by actual unfavorable events or by the perceived imminent risk of such changes. While a change or consolidation may be a response to the selection pressures, it was also observed that both types of systems have the capacity to reinforce themselves. The singular policy action system is driven by its self-referential nature that reconfirms its workings and definition of system boundaries whereas the composite policy action system is driven by further dissipation in an attempt to be comprehensive. Both methods have their advantages and disadvantages, but the latter seems to be better able to generate symbiotic coevolution while the first seems to alternate between parasitism and interferential coevolution.

Fifthly, selections and selection pressures of coevolving systems have a reciprocal quality insofar as the degree of freedom of the policy action system is limited by events and developments outside the intended control of the actors within the system. Not only can the

attractor basin containing the possible future states of the systems be compromised through adverse, unintended results and events, but the nature of the policy action system can also change partly by accident as a singular policy action system may not be aware of its singularity and a composite policy action system may not be able to keep its expansion into more variety under control.

Sixthly, in observing that the policy action systems' abilities are limited outside their intentional control, it is still able to have an impact on the physical system. Singular policy action systems have a smaller chance of taking into account all the possible future attractors of the physical system than composite systems. However, composite systems remain subject to the mechanisms that are inherent in coevolution and their composite nature therefore cannot guarantee that unfavorable developments will take place – it can only reduce the possibility of the occurrence of such developments.

Actors within the policy action system and the dynamics of the policy process have influence over the physical system but this influence is limited or distorted because of the six aspects described here. Policy makers are as much subject to selection pressures from the physical system and the societal environment as they can cast selective pressures on them. Coevolution between the systems is therefore a matter of reciprocal selection with the results not fully determined by intended selections made by policy makers but stemming from the entire complex of reciprocal selections. While parasitism can bring with it favorable effects in the short term, it can relapse into interference because of the reciprocal nature of coevolution. Achieving symbiotic coevolution seems to require dissipative self-organization but there is no guarantee that this will lead to the intended results as the influence of the policy action system is limited within coevolving systems.