NOTHING MORE PERMANENT THAN CHANGE

Or how to understand continuity in technological development

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Abstract

The calls for change are all around us. Modern society would need to dramatically shift to other production methods, other approaches to nature and environment, and new, improved regulations for economic activities. This paper does not challenge this need for more elegant production methods nor does it aim to criticize the importance of sustainability. What I will do, however, is question the concept of changing itself. More often than not, a need for change is accompanied with a claim of a paradigm shift actually already happening. I will argue that it is theoretically impossible to know whether one experiences a shift or not, as one would need to see in the future to actually proof the shift. With several examples from historical analysis, on management of river systems in the Netherlands and irrigation development in the Netherlands East Indies, this argument is sustained. It will become clear that pointing to actual shifts is not that straightforward, even when we know the outcome of the shift. There are clear changes to be detected in history, but when was the shift? Analysis of shifts will prove to be at least partly a function of the perceptions of the observer, the amount of time between the shift under study and the observer, and the length of the time frame applied in the analysis. Now being able to locate actual shifts may hamper, or at least leads to questions, about management of shifts in modern times.

Keywords

Continuity, change, paradigm, technological regime, water

1. Introduction

In 1993 I graduated as an irrigation engineer at Wageningen University. I must confess that I did not really consider that as strange. Obviously, as anyone, I did know that the Netherlands' international reputation is one of water excess, or drainage, not of water needs, or irrigation. Furthermore, with an MSc thesis on irrigation in the Netherlands East Indies, I knew that Dutch irrigation efforts on Java were substantial. It was not until I started to work at Delft University of Technology, however, that I realized that at least two questions needed explanation. The first issue seemed rather straightforward. One could still graduate in irrigation engineering in the late 20th century in the Netherlands, in Delft or Wageningen, because the Netherlands promoted its water knowledge within the international arena of development cooperation. Irrigation projects were vital elements within development policies. A second issue popped up, however, when I started looking at irrigation education in Delft. Within the lecture notes, I encountered many elements apparently taken directly from examples from the Netherlands East Indies. Specific discharge measurement structures were to be applied, and canal capacities were to be calculated according to a certain procedure. How could I explain the survival of these Dutch colonial elements within the general discipline of irrigation? This apparent persistency of colonial irrigation elements in Dutch irrigation practice and education is the starting point of this paper. In the second part of the paper I discuss a Dutch example of continuity in river management. I conclude with some remarks about understanding technological change.

2. Persistency: the example of irrigation

Accounts of persistency of colonial irrigation practice have been made by several authors. Colonial British irrigation design and water management concepts still shape to a large extent daily irrigation practices and discourses in Pakistan and India (Ertsen, 2010; Van Halsema, 2002; Mollinga, 1998; Bolding et al, 1995). Different ‘schools’ of irrigation development, similar to the British example, emerged in the context of colonies, as the Dutch did in the Netherlands East Indies and the French in north-western Africa. The American school may be the only one without colonial connotation, although elements of Spanish influence can be detected (Horst, 1996; Dahmen, 1997; see for example Glick (1972) for Spanish influence on the USA). An irrigation school is a tradition of practice, comprising information physically embodied in a community of practitioners and in rules for action which these practitioners master. Traditions define accepted technical operations and encompass aspects of relevant scientific theory, engineering design formulae, accepted procedures, specialized instrumentation, and usually some kind of ideological rationale (Constant II, 1980, 10; see also Downey and Lucena (2004), Picon (2004)). An important mechanism in this process of preference-guided selection of design solutions is engineering education; graduating from engineering programs is like passing the preparatory demands for community membership.

In the 1960s and 1970s, irrigation engineers developed irrigation schemes applying the well-known design practices of their respective schools, which were treated as 'the best possible method' (Dahmen, 1997; 100). Nowadays, modern irrigation science appears to the observer as an international, homogeneous body of knowledge. There seem to be no different schools of thought; one could speak of the modern paradigm of irrigation promoted by the World Bank, the International Commission on Irrigation and Drainage and other international organizations. Perhaps this international paradigm is dominated by American irrigation science. However, when looking closer, a somewhat more complex picture showing different approaches to irrigation and its problems replaces the picture of uniformity. Within irrigation modernization discussions French-based downstream controlled demand management and American-based upstream controlled arranged management approaches seem to be contrasted (like in Plusquellec, Burt and Wolter, 1994).

3. Continuity and change

With an obvious restriction in the empirical material being limited to Dutch irrigation and river management, even such a limited focus should allow me to contribute to a continuous debate within the community of those who engage with the history of technology, a debate which has been pointed out by Reynolds (2001). Traditionally, studies on histories of technologies focused on the bolts and nuts of technologies and its great inventors, with hardly clear and systematic exploration and explanation of the societal context. Brave men and their machines was the discourse. As a response, particularly in the last three decades, studies of technological systems, social construction of technology and the influence of class and gender have enriched the field of history. There is not much sense in denying that in many of the earlier studies the relation between technical development and society has been represented quite one-sided in terms of discoveries, inventions and successful applications of individuals who brought their discovery from its isolated niche in the open for society to prosper. On the other hand, though, new approaches focusing on understanding technical development as determined by societal forces allow society to determine shape and selection of technology, but technology hardly overcomes a status of passive artifact. Furthermore, daily activities of those engaging in developing technologies, our former heroes, are usually left out.

When this well-known discourse between internal and contextual approaches is presented, the author usually claims that he has overcome the differences. Indeed, my claim is not very original, but I intend to do credit to both approaches in my analysis of Dutch colonial irrigation. I discuss technical development as a process influenced by societal forces as well as by successful discoveries or applications by individuals. The concept of technological regime I apply aims to link the two positions (compare with Franssen (2002)). The regime concept is based on the recognition that 'invention and innovation are conditioned by such factors as earlier innovations, the search heuristics of engineers in an industry, available technical knowledge, market demand and industrial structure.' (Van de Poel, 2003; 49). The regime concept bridges another gap as well, as '[b]etween the formalized knowledge that can be traced through courses and treatises, and the everyday decisions made by engineers, there must be for sure some kind of intermediate know-how.' (Picon, 2004; 424) This intermediate know-how, transformed in rules structuring the how and what to do, shapes a technological regime. Engineering education, transferring existing knowledge and design rules to new engineers who have no direct link with the practice in which the rules were developed, can be considered as a structuring element. Another such a structuring element closely related to education materializes in engineering handbooks. Successful approaches become examples, even blueprints for technological design. Selected examples are presented to students at engineering schools. The professional engineering organizations, including educational institutions, but also Departments of Irrigation (or generally Public Works), select, discuss and promote successful technological solutions. Gradually, a technological regime develops.

Technological regime development is a two way process between structures and actors. I define a technological regime as a set of rules structuring activities of actors involved in development and use of a certain technology, inspired by Giddens' propositions (Giddens 1979, 1984) and guided by Van de Poel (1998; 2002). Rules can vary in form and content; some are related to design of technologies, others to use, others to divisions of labor. 'Some rules will be explicitly laid down in requirements and technical norms. Other rules will be tacit and implicit and will be followed by the actors on the basis of habits or tacit knowledge. […] Rules in technological regimes can also be embodied in production apparatus or technological artefacts.' (Van de Poel, 1998; 16) The totality of relevant rules shapes the technological regime. Within a technological regime different categories of rules can be ordered hierarchically; I employ five categories from Van de Poel (1998; 17). Together these five categories shape the technological regime (figure 1).

Basic founding premises are (1) 'guiding principles', which relate the design of a technology to doctrines and values used to legitimize a tradition and its outcomes. Closely related to these principles are the (2) 'promises and expectations' about a future technology, which will be translated into more specific requirements for new technologies. I employ the term (3) 'design requirements' to describe functions to be fulfilled by an artifact and boundary conditions that are important in the design of a technology. To enable the fulfillment of requirements, (4) 'design tools' are employed, including scientific knowledge, design heuristics, technical models and formulas, design methods and approaches. Category (5) 'artifacts and operation' includes the result of any design activity; both in the meaning of physical objects as in the meaning of operation and management procedures. Artifacts may not be considered as rules, as they only fulfill functions and have to meet design criteria and requirements. On the other hand, artifacts can and certainly do function as exemplars: future designers still apply them because they are known or have been proven in practice. The categories are structured in a hierarchy; guiding principles are on a higher level than design tools. In the Netherlands East Indian context, higher level not only refers to the more abstract nature of guiding principles in contrast to for example design tools, but also to the larger number of stakeholders involved in and the political connotation of formulating guiding principles. Debates on the appropriate foundations for colonial water policy involved civil servants and engineers, government and private industry; discussions which discharge measurement structure to be used to realize this water policy were exclusively situated within the civil engineering circle. Higher level rules structured the development process of lower level rules like design tools and artifacts.

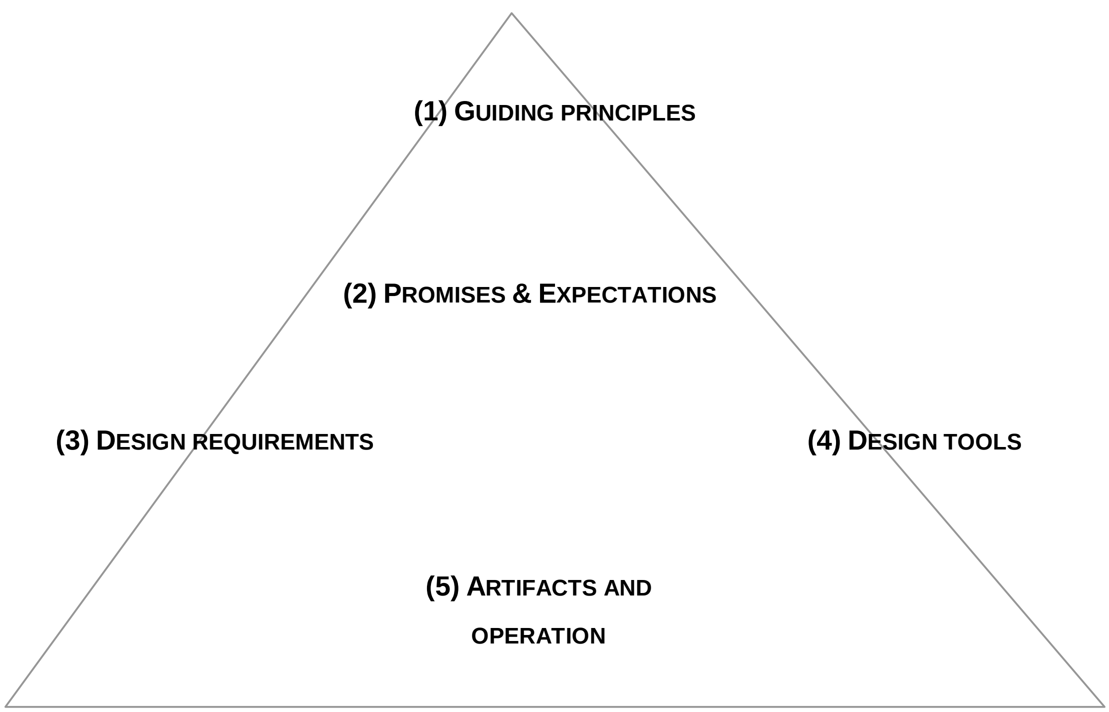

Figure 1. The technological regime triangle (rom Van de Poel (1998; 17))

4. Structuration

The extremely simplified description of regime development given above has some apparently functionalistic connotations: rules on one level shape rules on lower levels. Such a description obviously will not do at all for a better understanding of technological regimes. Functionalism is the last thing I want to defend; humans, not abstract forces, created the irrigation works and knowledge in the Netherlands East-Indies. I am much more interested in conceptualizing technological traditions in the way Giddens discusses the concept of structure. Sewell (2005) provides a further, highly useful elaboration of Giddens' theories. As I only apply some restricted ideas of Giddens, basically the idea of rules having a social history and future, I do not include a detailed discussion of Sewell's improvements of Giddens in this paper. ''Structure' refers to 'structural property', or more exactly, to 'structuring property', structuring properties providing the 'binding' of time and space in social systems. […] [t]hese properties can be understood as rules and resources, recursively implicated in the reproduction of social systems.' (Giddens, 1979; 64) Structures do not exist; they manifest themselves through the constituting moments of social systems. This '[…] implies recognising the existence of: (a) knowledge – as memory traces – of 'how things are to be done' (said, written), on the part of social actors; (b) social practices organised through the recursive mobilisation of that knowledge; (c) capabilities that the production of those practices presupposes.' (Giddens, 1979; 64)

Regime development is a social activity; in social interaction human actors construct technological regimes as they construct society. 'Human social activities, like some self-reproducing items in nature, are recursive. That is to say, they are not brought into being by social actors but continually recreated by them via the very means whereby they express themselves as actors. In and through their activities agents reproduce the conditions that make these activities possible.' (Giddens, 1984; 2) Generally, in daily practice we reproduce existing, historically grown sets of rules by applying and changing them. To know a rule is to implicitly know what one is supposed to do in particular situations and rules are widely used and sanctioned. Although they show a tendency to be stable, rules are not static (Giddens, 1984; 17; see Franssen (2002) for a critique on Giddens, especially his 'rule' concept. See also Sewell (2005)). Rules do not develop by themselves, nor are they followed simply because they are there. Actors, real people, make and break rules. Actors will follow the relevant rules, or in my case act within the technological regime, not just unconsciously or routinely, but also because they think they have something to lose by not acting in accordance with the rules, or something to win if they do (Van de Poel, 1998). Human activities are recursive. Structures, regimes or rule sets, do not exist as patterns in time and space by themselves, but only become concrete through human action; society is reproduced through human action. What remains somewhat unclear from the discussion above is where the action actually is.

5. Irrigation in the Netherlands East Indies

Dutch colonial irrigation activities started on behalf of the European sugar cane cultivators in the 19th century, but later efforts were also directed at supporting and improving the rice-cultivation methods of the indigenous population (Ertsen 2010). An early issue was irrigation revenue. Within the so-called Cultivation System ('Cultuurstelsel'), introduced by Governor General Van den Bosch in an attempt to make a profit from the colony after the Java war (1825–1830), Javanese farmers had to cultivate certain cash crops. When in the second half of the 19th century the Cultivation System was gradually replaced by a policy of free trade and production, the colony still had to deliver a profit for the mother country. Irrigation development was seen as one of the areas for the colonial government to endorse profitable economic production as well as food security. The commercial crops were grown in the same areas and fields as used for rice; the commercial agricultural enterprises did not own land as they would have done in a plantation system, but rented land from the Javanese farmers. From the first colonial irrigation efforts onwards the irrigation systems in the East Indies irrigated both sugar cane and peasant crops, rice in the wet West Monsoon between October and March/April and dry crops ('polowidjo') in the dry East Monsoon. Water had to be distributed to all these crops through the same canal system. Therefore, water distribution methods were designed to divide, distribute and measure the water between commercial and food crops in a just way. After discussions at the end of the 19th century on what 'just' actually meant and how it could be achieved, a centralized water management system developed, with engineers in charge (Ertsen, 2010). The simultaneous presence of commercial and food crops within the same irrigation system shaped both colonial Dutch irrigation infrastructure and management.

In the beginning of the 20th century, when colonial irrigation engineers had established the foundations of a more systematic approach to irrigation design, many engineers admired their pioneering colleagues. 'Precipitate working, without preceding study of water levels and discharges, let alone of other hydrographically important circumstances, virtually became the rule. Therefore, works […], designed with gross underestimation of flash flooding capabilities of the rivers, often flushed away. Others, constructed without knowledge of lower discharges, disappointed in their water delivery.' (Weijs, 1913; 8) Especially in the first half of the 19th century the 'permanent' engineering structures were destroyed or seriously damaged by 'bandjirs' (flash floods) as quickly as the indigenous 'temporal' structures. One of these early structures constructed by Dutch engineers was a weir in the Sampean River, on the eastern outskirts of Java, in 1832. This dam was replaced several times by others, which suffered heavily from flash floods too. In 1887 a more satisfactory solution was established, with a combination of weirs, sluices, river improvements and bypasses. Even then, the rapid floods of the river could damage the structures considerably, as in 1916 (Ravesteijn, 1997).

The establishment of the Bureau of Public Works in 1854 was a political recognition of the potential role of engineers and technical support in colonial irrigation development; a main task of the Bureau was constructing irrigation works on Java. The engineers remained subordinate to the Civil Service, however; the 'Resident' (administrative representative of the Civil Service on regional level) usually took the initiative for irrigation development. Civil servants did not always call for the help of engineers though. Furthermore, the Bureau had to cope with lack of financial means and personnel; even in cases civil servants required support the Bureau could not always provide it. An engineer who devoted his career to improve the position of the irrigation engineers within the colonial state was H. de Bruyn, director of the Bureau between 1861 – 1868 and 1874 – 1877. Although he certainly did manage to increase attention for irrigation expressed in the growing number of preparatory studies, the actual number of projects realized was low before the last decennium of the 19th century. The quality of the works realized did improve, however, which strengthened the position of engineers.

In 1885, the Bureau of Public Works became independent from the general Civil Service. The new Department of Public Works became the centre of irrigation activities. A so-called Irrigation Brigade had to study possibilities to provide all governmental lands with modern irrigation facilities. In 1890 the General Irrigation Plan for Java defined 19 irrigation projects to be developed; some other projects were included in 1907. Most of these projects were located in East or Central Java. The importance of preparatory research increased, and the new approach of the engineers reflected the idea that irrigation systems needed to be considered as a 'coherent organism (Lamminga, 1910; 5). Research on rainfall, river flows, soils etcetera was to be used for the design of irrigation systems with both head works and a network of canals and drains. Just two years before the General Plan, the first Irrigation Divisions ('Irrigatieafdelingen') had been established. These management units on the level of river basins were responsible for design, construction, exploitation and maintenance of irrigation. Daily management within irrigation systems was arranged through regulations defining procedures for the allocation and distribution of irrigation water to different crops and use(r)s. Generally speaking, water distribution to sugar cane was separated from distribution to rice.

The economic aspect of irrigation works was emphasized in 1897 with the establishment of the Rentability Commission, which had to study costs and benefits of irrigation projects; economic effects of irrigation development had to be quantified. The cost-benefit criterion increased in importance in the context of the Ethical Policy introduced in 1901 (see Moon ,2007; Fasseur, 1993; De Jong, 1998; Jonkers, 1948). New welfare measures had to improve the position of the Javanese, but although the focus on profit from the colony was softened somewhat, measures on the terrains of irrigation, emigration and education were to be checked from an economic point of view. Another influence of the welfare policies was a growing attention for Javanese agriculture. Agricultural experts from the Department of Agriculture, established in 1905, entered the irrigation scene. Irrigation was important in the welfare approach. Not everything the irrigation engineers did, however, was successful. The plans in the Solo Valley proved to be a case in point. At the end of the 19th century it became clear that the project costs were much higher than anticipated and the project was suspended in 1898. The Minister for Colonial Affairs appointed a committee to study the Solo plans. The committee advised continuing the irrigation part of the plan (Telders et al, 1900). In 1903, Minister for Colonial Affairs Idenburg decided to follow the minority advise to cancel the project altogether.

The abandonment of the Solo project was perceived as a lack of confidence in engineering and seemed to set a temporary halt to larger-scale irrigation development. The General Irrigation Plan, however, was continued as planned. The irrigation engineers had successes to show too, with as main example of a successful irrigation system the Pemali system, with an irrigated area of about 45,000 bouw. Developing water infrastructure was too important for colonial policies not to involve specialists who had proven their capabilities. In the early 1920s, when the first General Irrigation Plan was completed and colonial policies returned to normal after the First World War, a new set of irrigation projects was defined. The budget for irrigation reached its peak in this period with around ten million guilders per year. The number of engineers employed by the Department of Public Works passed 200 in the early 1920s and reached its maximum of 263 in 1930. Irrigation design procedures in the 1920s did not differ much from those applied in the 1890s, although formulas and artifacts had changed. Hydraulic laboratories in which designs could be tested brought a new dimension to design, although irrigation practice remained a determining factor within the engineering community. Both the economic recession of the late 1920s and the growing nationalistic sentiments on Java reinforced governmental attention for irrigation development, as it served food security and thus social stability. In 1936 a General Water Regulation for Java was established; it was the first general water regulation in the colony, and the last…

6. The colonial irrigation regime

Colonial irrigation was a juggling act (Stone, 1984; p8) between available labor from colonizers and colonized, available financial resources and political goals influenced colonial irrigation development. Irrigation development in the colonies did not only serve the colonial powers, but also had to serve the colony itself; it should not be exploitation, but become an element of productive imperialism. Agrarian policies of the colonial power appear as vital in explaining colonial irrigation approaches. Different types of rules and/or guidelines were employed in East Indies irrigation design; an important guiding principle was – anticipating on – the presence of sugar cane next to rice in the same irrigated area. This required control over flows varying in time and space. This guiding principle was translated by civil engineers into a design approach. Artifacts and methods developed by Dutch engineers in colonial times still shaped to a large extent irrigation design practice in independent Indonesia and Dutch civil engineering irrigation education.

All this resulted in a Netherlands East Indian irrigation regime. To start at the end, in 1940, the Dutch irrigation regime with its main features had three main guiding principles. 1) Sugar cane and rice were mutually present in irrigated areas, and 2) economic optimization of irrigation water was to be achieved. Between 1920 and 1940, another main focus of irrigation policy was added in 3) developing empty areas through irrigation, including the coastal plains of Java and systems on other islands like Sumatra and Sulawesi. The regime did not grow out of a single, linear regime development process between 1830 and 1940. The set of design rules was shaped by human actors; they did so in a social construction process in different natural and social environments. In and through their activities the human actors reproduced the conditions that made these activities possible and created a regime. The relation between sugar cane and rice remained on the agenda up to the 1930s; many problems with the mutual presence and some solutions were debated upon and tested, although the mutual presence of the crops itself was not discussed. The agrarian-political context of Dutch colonial irrigation set from the Cultivation System onwards did not really change. Commercial and food crops needed to be irrigated with the same irrigation infrastructure; sugar cane and rice had to share the same irrigation facilities.

Between 1830, with no irrigation regime whatsoever, and 1940, with a well established irrigation regime, a clear transformation has occurred. I now turn to the question whether this transformation process did include subsequent regime changes before the final 1940 regime or not. How gradual was the transformation? It has been argued that '[…] in the irrigation development in colonial Java various technological regimes can be distinguished.' (Ravesteijn, 2002; 363) According to this view, when colonial irrigation activities recommenced with full swing after World War I, '[…] a new generation of irrigation projects that differed in main outline from what had gone before […]' (Ravesteijn, 2002; 383) started. These new systems would be different regarding irrigation management, agricultural aspects of projects, reservoir construction technology, the step-wise approach to the creation of irrigation works and the development of laboratory facilities (Ravesteijn, 2002; 382). I disagree with this view and argue that differences, if any, between the generations of irrigation projects before and after World War I are not significant and can be explained much better within a framework of regime continuity than in terms of regime change. Approaches and methods developed between 1885 and 1914, mainly in the context of the first General Irrigation Plan, were a stable foundation on which a new generation of irrigation projects could be developed in the 1920s and 1930s. Guiding principles and the design requirements were formulated in the early period, whereas the design tools and artifacts showed a more continuous development over time, with relatively many new tools and artifacts being develop in the second period. When working on the second generation systems, civil engineers could discuss and select design tools and artifacts to further shape the Dutch irrigation regime. 'Closure' of the principles and requirements occurred much earlier than 'closure' of tools and artifacts (compare with Bijker, 1995).

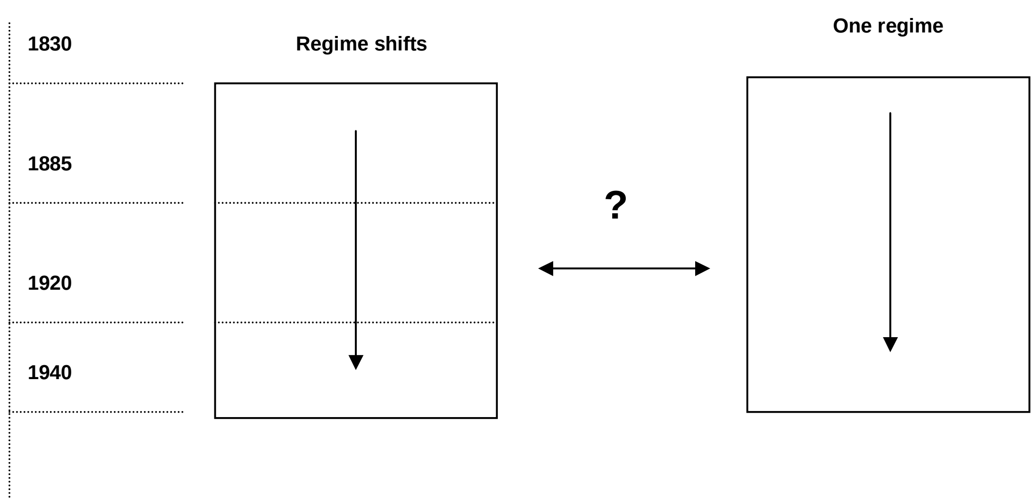

Figure 2. Two regime development positions for the Netherlands East Indies

Thus, I argue that the new generation of irrigation projects on Java of the 1920s did not differ fundamentally from the generation before; the new systems were designed with the same reasoning and procedures as their ancestors. Changes in elements, particularly artifacts and design formula applied, did not change the design reasoning and procedures already established around 1900. Actually, the second generation projects realized the basic principles of colonial water management through application of new hydraulic insights and artifacts. In other words, the irrigation regime development process in the Netherlands East Indies did not include a regime shift. I am on the right in figure 2. I think it is reasonable to accept a shift from one technological regime to another only in case a major part of the guiding principles and promises/expectations, together with part of the design requirements, would change. A technological regime is transformed if one or more of its core or constitutive rules changes (Van de Poel, 2003; 52). The guiding principles for Dutch colonial irrigation, the core rules vital for the continued existence of a technological regime, were defined in the early phase, before many of the more peripheral rules of tools and artifacts were defined in the second phase; the core rules have not profoundly changed over time. The peripheral rules are important enough; after all they do give shape to the regime in design practice, as we have seen for the post World War II period. However, they are not constitutive for a technological regime as such (Van de Poel, 2003; 52; see for a much more detailed analysis Van de Poel, 1998). Between 1900 and 1940 no major changes have occurred in the regime rules on the higher levels, with one exception. A new constitutive element was added in the focus of the late colonial state on empty areas. This change in focus from the early, smaller systems of East and Central Java to the larger settlement schemes may have changed the working context for regime elaboration, but it did not influence existing guiding principles.

Not being able to distinguish different regimes over time does not imply whatsoever that one could not distinguish phases in the regime development process in the Netherlands East Indies. Although I would argue that it is not possible to define these phases as representing shifts or changes in direction of the regime, I do think that it is possible to recognize a certain pattern in the regime development process. Before presenting the phases I distinguish, we may take a look at the periods proposed by others.

Four phases are quite often distinguished, for example in the general description of irrigation development by Van Sandick (1912), which has been brought back by Ravesteijn (1997; 363-364) to a shorter version, although the distinction between the last two phases was much more an expression of the wishes of Van Sandick than reality, as he wrote his history in 1912:

- Before 1872: indigenous irrigation, with engineering interventions from 1832
- Between 1872-1888: technical measurements and construction of systems
- Between 1888-1912: technical water management
- From 1912: onwards agricultural water management

Another distinction, focusing on the engineering aspects, applies three phases (Vlugter, 1949):

- Before 1900: a pioneering phase
- Between 1900-1925: increasing construction activities
- Between 1925-1950: liberation of fixed shapes and perfectionism

A distinction in regimes, related to the formation process of the colonial state, would be (Ravesteijn, 1997; Ravesteijn, 2002):

- Between 1832-1885: semi-technical regime, traditional colonial state
- Between 1885-1920: technical regime, transformations in the colonial state
- Between 1920-1942: technical-agricultural regime, modern colonial state

It is clear that defining phases is a function of the present: those looking further back define longer pioneering phases and apply more general distinctions between phases (Ravesteijn, 1997; 364). Not escaping this law of the distant observer, I propose a distinction in two phases in the development process of the Netherlands East Indian irrigation regime between 1870 and 1940. The phase between 1870 and 1910 can be best understood as the formative phase of the regime: the phase in which the guiding principles, promises/expectations and the majority of the design criteria took their shape. The focus in this phase was on developing prescriptions for irrigation design. The phase between 1910 and 1940 can best be understood as the elaboration phase of the regime: the phase in which the tools and artifacts to translate the general rules into physical infrastructure were defined. The focus in this phase was on perfecting the tools and artifacts applied in irrigation design.

It is probably not necessary to remark that it is rather difficult to pin these two phases on exact years. If we should vote for one year representing the phase change in my two-phase model, a major candidate is the year 1900, when the Solo Commission published its report; the report probably symbolized the end of the (short) political freedom of the civil engineer, but probably confirmed the technical approach developed by the engineers so far. Although it took to 1920 before all elements were finalized, 1910 represents the practical realization of the first General Irrigation Plan for Java, at least in financial terms. The whole period between 1900 and 1910 can be viewed as turning period. Whatever the exact years, it is clear that in the early period the higher level rules and the most important design criteria were defined, whereas the later phase focused on the tools and artifacts. For practical reasons, and also because this event did influence the relations between colonizers and colonized significantly, I would propose using 1914-1918, World War I, as the phase change. After World War I, the last two-and-a-halve decades of colonial rule were the scene of renewed irrigation activities. Unlike World War I, which only set a temporarily halt to expenditures and did not change the irrigation regime, World War II forms a demarcation for the Netherlands East Indian irrigation regime. After World War II, the new political realities caused a major shift in context for Dutch irrigation activities; Indonesia disappeared as secure field of practice. This disruption of colonial realities after 1945 was not unique for Indonesia and the Netherlands; within 20 years most colonies gained their independence and were redefined as 'developing countries'. In this new reality Dutch irrigation engineers started to work in countries worldwide; the first generation did so with their experience in the Indies embodied in their persons, the second generation did so based on their education and training in Delft. Dutch engineers started working in other tropical regions, engineers from different countries started to work in independent Indonesia. Although the new working realities for Dutch irrigation engineers were recognized and explicitly taken into account to defend continuation of the Delft irrigation program, the study material suggests that irrigation engineering in Delft maintained being approached as application of design prescriptions developed in the Netherlands East Indies. The fact that until the 1980s, all irrigation professors in Delft gained their working experience in the Netherlands East Indies is probably part of the explanation.

7. Lessons from the Netherlands East Indies

The Dutch irrigation regime did develop over a period of 110 years; the general rules, guiding principles and promises/expectations, were translated into design requirements in the second half of the 19th century, whereas a standardized realization of these requirements emerged in the first half of the 20th century. There is indeed a relation between politics and design; next to artifacts and systems useful for the fulfillment of needs, engineers (designers) bring along a new societal reality. Engineers change society with their designs, sometimes without deliberate purpose, often on purpose. The Dutch irrigation engineers in the Netherlands East Indies knew that they were changing society. They wanted to change society, improve the colony and improve the lives of the Javanese. Engineers were busy creating locales of happiness, or so they thought (Ertsen 2010; Mrázek, 2002). Nevertheless, the influence of the political context, perhaps better formulated as 'broader social circles than engineering alone' on daily practices of engineers may be limited. I do not argue that engineers are isolated from the outside world; again, engineers are performing many roles in society and do engage in many political debates. Daily engineering practice, however, may be much more influenced than we recognize – or like for that matter – by what their engineering predecessors defined as 'good practice' and not by societal debates. Proposals made by designers have to meet standards. Internal documents, often formulated as design guidelines, produced within the engineering community play a very important role in building frameworks and maintaining continuity. Guidelines are intermediates which store information available to the design engineering network. Storage in networks representing technological regimes permits time-space distantiation: old guidelines structure later designers. Recognizing this would include recognizing the need to further clarify relations between communities of engineering practice on the one hand and relations between societal discourse and technological design on the other.

8. Dutch river management

Let us move to our second case study, Dutch river management and flood management in particular. An outsider could easily think that Dutch water management is changing dramatically. A multitude of recent publications, both in scientific journals (for example Vis et al 2003) as policy papers (like Commissie Waterbeheer 2000) suggests that flood management in the Netherlands is about to change: a (perceived old-fashioned) construction based strategy (usually embankments and/or hydraulic structures) would change towards a modern strategy of 'living with floods', 'room for the river' and 'resilience'. This new strategy would imply that effective flood policies should be based on working with water instead of fighting against it; a major element is that policies should focus on the question how to prevent damage instead of how to prevent floods. In Dutch river flood management a perceived new strategy is promoted: resilience. The Dutch river system needs to become resilient. Although the exact meaning of this term is subject of debate within the water sector, the general interpretation of resilience tends to focus on relations between flooding and the resulting damage. Strategies which would minimize damage would be the most resilient; this could include deliberate flooding of certain areas to prevent the flooding of other areas. The approach is promoted as new and contrasted strongly with the perceived old-fashioned strategy of protecting all the land at all costs. Apart from definition problems – is resilience in such an approach a capacity of the water system or of the protected areas? – one could question the claim that a focus on damage reduction is new indeed. One could also question if the measures proposed are new; after all, measures like river diversions which flood areas to prevent high water levels downstream are a well-known phenomenon in the Dutch river system. Applying the concept of technological regime, this example shows that although procedures applied and measures proposed may be new occasionally, the proposed 'new' strategies can be understood as a continuation of already existing strategies of flood damage reduction in the Netherlands.

9. Undesirable 'Russian Roulette' (Vis et al, 2003; 38)

After the near floods of 1995 and 1997 the call in the Netherlands to develop new measures for flood management gained importance. In first instance embankments were to be strengthened and heightened, but new voices were heard that this policy would not be enough to cope with peak discharges in the future. Due to climatic changes, these peaks were expected to increase from 16,000 m^3/s to 18,000 m^3/s or perhaps even 20,000 m^3/s. The room for water to flow in the river bed would have to be increased, for example by removing obstacles in the river bed. The measures of creating room for water within the river bed, although not aiming at river training, come close to 'traditional measures'. 'Traditionally, attempts to reduce the flood risks have focused on river training and the construction of embankments. Such measures aim to reduce the flood hazard, i.e. the frequency of flooding. Flood risk management strategies based on this approach are called flood control strategies or "resistance strategies". ' (Vis et al 2003, 33). These 'resistance strategies' are, however, supposed to be unsafe: embankment breaches and consequent flooding can occur at any place during a peak discharge. 'The course of events is consequently unpredictable. This form of "Russian Roulette" is undesirable.' (Vis et al 2003, 38).

Whatever is desirable, it is clear that increasing river discharges within the river bed could have its limits. Therefore, the Dutch debates on river flood management discussed measures to increase the discharge outside the river bed too. These measures aimed at creating water storage or bypasses; although originally not necessarily developed as such, they may be perceived as examples of a new strategy discussed within the Dutch river flood management discourse: resilience. 'Minimising the consequences of flooding, or learning to live with the floods, instead of reducing the flood hazard is another approach to lower flood risks. In this approach flooding is allowed in certain areas, while at the same time the adverse impact of flooding is minimized by adapting the land use. Such strategies are called "resilience strategies".' (Vis et al 2003, 33). The Dutch river system needs to become resilient. Although the exact meaning of this term is not too clear and subject of debate within the water sector (see for example Remmelzwaal and Vroon 2000), the general interpretation of resilience tends to focus on relations between flooding and the resulting damage. Strategies which would minimize damage would be the most resilient; this could include deliberate flooding of certain areas with low damage to prevent the flooding of other areas in which higher damages would occur. The approach is promoted as new; it is contrasted strongly with the perceived old-fashioned strategy of protecting all the land at all costs. The existing flood management possibilities have to be judged to check how resilient they are. This checking appears to be rather exact: with the application of hydraulic models water flow and flood patterns are simulated. Applying other modelling techniques the damages caused by the floods can be calculated. Vis et al (2003), a typical exemplar of this type of studies, present one example of outcomes based on this approach. In short, an 'area as a whole is more resilient if the less valuable parts are flooded prior to the more valuable parts, which are being safeguarded longest.' (Vis et al 2003, 34).

A first note is that the term 'resilience' is reserved for the land areas which are flooded or not; water systems themselves are apparently not included in the term. A second note on this description of resilience could be made on the a-historical use of the concept: the period in which an area is allowed to show its resilience is not given. Although it is a questionable comparison, one could argue that the Netherlands as a whole has shown considerable resilience over ages; after all, the country still exist, despite many floods from rivers and the sea. A third note one could make is that the terms used to describe the different approaches – 'resistance' versus 'resilience' – appear to include an a priori negative judgment on measures taken before by our predecessors. A fourth note is the subject of the remaining part of this paper: are the measures proposed indeed new and so different from what has happened before? More generally, is the approach in general new? We would argue it is not as new as is suggested, for four related reasons. Flood control should ensure that the Western part of the Netherlands, with its high economic and demographic value compared to the Eastern Netherlands, is protected. The measures proposed (extra river courses or temporary side spills) have been discussed extensively throughout the Dutch river flood management history. Theoretically it is not at all likely that such a 'sudden change' would occur. The resilience approach, like any other approach, is meant to increase water control: instead of the rivers human agency should decide what to flood.

10. Protecting the West

In the current discourse on river management, the normalization of the rivers in particular is perceived as the main problem. The Dutch rivers are 'forced' in their beds, with the consequence that they cannot flow freely enough to discharge their flood water. Creating room for flood discharge through extra permanent water ways (as was frequently done in the past) cannot be applied anymore in the densely populated parts of the Netherlands; creating room within the river bed and temporary measures outside the river bed are proposed as solutions. The economic and demographic important western part of the Netherlands needs to be protected. In the historical discourse on flood management (see for example Van der Ham 2004) all these elements are included too. Van der Ham concludes that in the 18^{th} and 19^{th} century protection of the 'heart of Holland' (the western Netherlands), being the lowest and the richest part of the country, had always the highest priority. The (in)famous Diefdijk – literally translated as 'Embankment of Thieves' – is one example: it was constructed to prevent water to flow from East to West. It was controlled by water-boards from the West (Van de Ven 1996). Discussing and creating room for floods outside the river beds has been an element of river management in this period too (Van der Ham 2004; Van de Ven 1996), like river diversions and spills (figures 3 and 4). One of the diversions, the Beerse Maas or Beerse overlaat was situated between the cities of Cuijk en Grave; it consisted of two river stretches without embankments – reason why it is not completely accurate to refer to the system as a side spill – of 800 and 2.500 meters (Van der Ham 2004; figure 3). When the river discharge was high, water would flow naturally in the Beerse Maas; a gun would be fired to announce this moment.

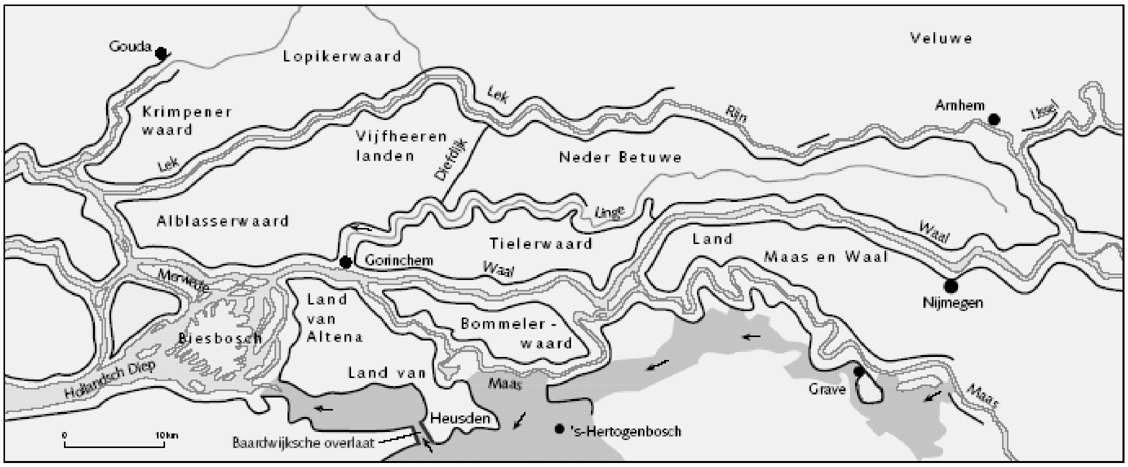

Figure 3. The system of spills in the province of Brabant in the 19th century (Van der Ham 2004)

In 1821, a commission discussed the effectiveness of the system: the water encountered so many obstacles like hedges, roads etcetera that the flow was hindered seriously (Van der Ham 2004). Although attempts had been made before to clean the water course, these had not been very successful. Van der Ham (2004) mentions that from 1828, the system was functioning better. The related '*Baardwijkse overlaat*', constructed in 1766, was enlarged too; this spill had to drain away part of the water diverted by the Beerse Maas (Van der Ham 2004; Van de Ven 1996). A major problem in the Dutch river area, however, causing most floods, were the ice dams; besides regulating and maintaining a trustable depth for shipping, the river normalization works in the Netherlands were also executed to prevent the formation of ice dams by increasing the speed of flood discharge through the rivers. The Beerse Maas was closed in 1942 after the normalization of the Maas (Meuse) was realized (Van de Ven 1996). One of the measures proposed in the flood management debate in the Netherlands to realize temporary storage and/or extra discharge capacity was reopening the Beersche Overlaat (Commissie Noodoverloopgebieden; figure 4). One of the points of discussions was the effectiveness of the system: the perceived water trajectory still included many obstacles, including houses and industry.

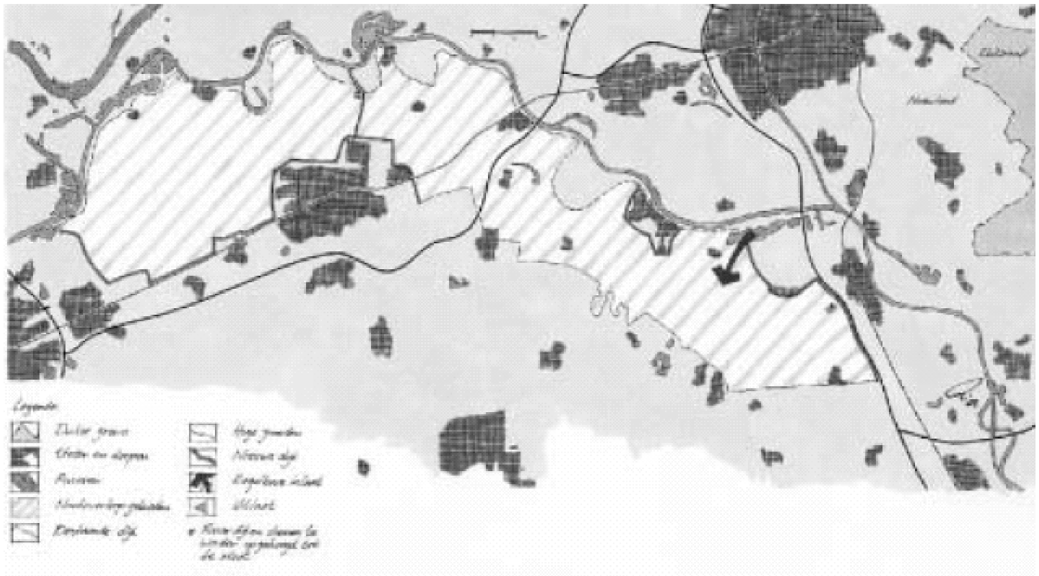

Figure 4. The ‘Beersche Overlaat’ as proposed by the Commissie Noodoverloopgebieden

So far so good: we have seen that several participants in the current Dutch flood management discourse promote new measures; furthermore we have seen that some of these measures are already quite old. We do know that the societal, environmental and technological context in which these measures are designed and managed have changed; but how can we understand continuities and discontinuities between different contexts in time? Let us again turn to technological regimes to discuss continuities and new elements in the regime. The focus on the western part of the Netherlands, with measures like spills as the Beerse Maas, was discussed. Analyzing one of the main documents expressing the so-called new water management policy of the Netherlands (Commissie Waterbeheer 2000) will allow further analysis of similarities and/or differences between new and existing flood strategies. One of the key sentences in the document reads very similar to a sentence we quoted above from Vis et al; the ‘old’ strategy is qualified. ‘‘Water management in the twentieth century was based on mastering water. Technical interventions enabled controlling water and draining it fast during high river discharges and much rain.’’ (Commissie Waterbeheer 2000, 25; author’s translation)

In other words, ‘water control’ is made equal to ‘(fast) drainage’. The report continues by stating that too fast drainage can lead to conditions being to dry in periods of low flow. Furthermore, the drainage capacity of the Dutch river system might become too low, due to sea level rise, changing river discharge patterns, but also due to changes in land use patterns (urbanization). Human induced subsidence, due to low ground water level in the western part of the Netherlands is also distinguished as cause of increasing risks (see Van de Ven 1996). New measurements are proposed by the Commissie Waterbeheer; instead of focusing on fast drainage of peak flows the Commissie proposes a strategy focusing on 1) containing water, 2) storing water and 3) draining water (with a preference in that order). This three-step strategy would favour ‘new’ measures (including emergency storage through spills) above ‘old’ measures like increasing the discharge capacity of a river or heightening embankments. Constructing embankments is not seen as a durable alternative by the Commission.’ (Commissie Waterbeheer 2000, 45), although in specific cases (like along the IJsselmeer) the Commissie does see a need to improve the embankments, including raising their level (page 46).

To ensure that all these measures are applied, appropriate legal contexts need to be available. Governmental institutions would need the proper legal authority to propose and develop measures, especially those with far-reaching consequences (which for example claim extra room or would flood certain areas). The Commissie itself acknowledges that these legal instruments are often already available (page 61); they are not used, however (page 30). Thus, measures proposed are not new, legal contexts do not need to be (re-) established (although they may need to be (re-) enforced). What has changed, one may remark, is the attitude towards water management: in stead of perceiving water as the enemy, water could be seen as an ally. Strategies like ‘resilience’ do not fight against the water at all costs, but accept that water needs room to flow; if one recognizes this, one could try to create circumstances favorable for both water and humans. Nevertheless, in new approaches control over water remains the key founding element of the strategy. The Commissie Waterbeheer argues that the Dutch water system ‘needs to be reliable at all times’ (Commissie Waterbeheer 2000, 36). Water management should anticipate on future developments, probably more than has been done before, but the bottom line is that the water system needs to be predictable and manageable. Vis et al, who propose a resilience strategy, make a similar remark. ‘The studied resilience strategies […] are structural solutions for a comprehensive flood management scheme […].’ (Vis et al 2003, 39).

I would therefore argue that although regularly suggestions are made that from now on Dutch river flood management needs to be based on new principles, in fact the same principle as for long times is being defended: human control over the Dutch rivers is vital to guarantee the existence of the Netherlands. Controlled flooding, emergency spills, diversions may be measures not applied for a long time – and new perhaps for some participants in the field – but they are not new. Applying them in the current timeframe is in line with the long-term desire of water management in the Netherlands: complete anthropogenic control over the river system. After all, even though occasional flooding of river areas may be unavoidable in future, the current management approach would like to plan flooding in advance! In terms of the regime triangle (figure 5), the guiding principle of river flood management in the Netherlands remains protecting Western Netherlands. Concerning the promises and expectations, one could argue that 'nature development' has become to play a more important role; this may be the case indeed, but control and prediction remain higher on the agenda. Design requirements are modified slightly, with strict safety levels being supplied with risk – damage – analysis. Growing power of design tools like modelling equipment has increased human potential to predict events and support decisions – although one should never overestimate models! The potential selection of artefacts has increased compared to what has been applied in the last 50 to 100 years, but as I argued not compared to the last 200 years or longer ago.

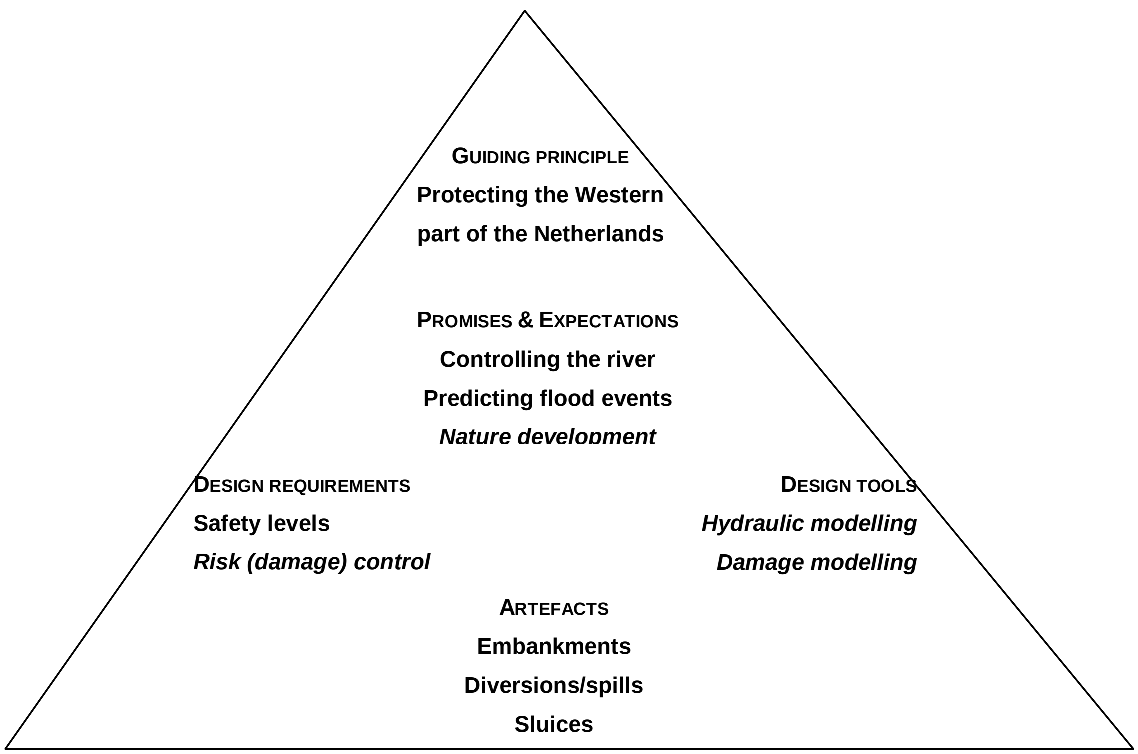

Figure 5. The Dutch river flood management regime triangle

11. Concluding remarks

The two regimes I discussed can be understood as mission-oriented innovation patterns, defined as patterns in which 'innovations derive from a mission formulated by a powerful actor acting as principal for the artefacts designed. Such missions define a framework within which innovations are accomplished.' (Van de Poel, 2003; 55) In a mission-oriented innovation pattern, main carriers of innovation/transformation are governmental agencies;

typical areas in which such a pattern is to be expected are defense, energy, communications and transport. The key position of engineers within colonial regime development is partly explained by the mission innovation pattern; if in such patterns the relation between the main actor and the innovators is close, also today. Such a situation, for example, existed at least until recently in the Dutch infrastructure section. In this sector, governmental agencies – pre-eminently the *Rijkswaterstaat* – act as client/principal, designer, researcher and regulator […]. R&D and design activities, to an important extent, take place within the same organization that formulates missions for technical projects.' (Van de Poel (2003; 55; note 11; emphasis in original).

Stressing continuity in the social construction process of Dutch water regimes does not imply that the regimes developed like some external force, with a will of its own, without any possibility for actors, either engineers, farmers, civil servants or any other, to influence its course. Fierce debates took place in the colony and the Netherlands, on issues of water allocation, regulation, distribution, flood protection, and others. Different social groups disputed over policies to develop, about the rules for engineering projects. Actual outcomes of this confrontation between social groups have been influenced by changes in political, economic and institutional settings. Different circumstances, changes in social contexts, value patterns etcetera could stimulate changes in technological regimes; new technological measures could be developed, other techniques may become obsolete. Without doing justice to the existing - rather enormous – body of knowledge and literature on – the history of – Dutch water management I question if such shifts can be detected; I argued that describing changes in terms of a shift would not be the most appropriate way. One of my arguments was that the guiding principles – for river management protecting the Western part of the country because of its economic and demographic value – have not changed. That is not to say that nothing changes: in river management measures proposed do differ from those applied in the last 50 years. They are not new, however, as they were known, discussed and applied before. The time frame one takes into account appears to be of importance here: what may be perceived a rather drastic change on a short time scale could become a much more gradual development on the longer time scale. Understand water management – or technological development – requires a longer term perspective. The concept of technological regime may enable grasping differences and similarities between the 'old' and the 'new'. As other networks of interaction, engineering communities show a certain degree of stability. Recognizing such stability may not immediately lead to improvements in water policies or designs, but understanding processes bringing about designs is a step to take anyway if one ever would like to improve them.

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