Sustainable use of phosphorus

Capturing the philosopher's stone

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Chapter 6

The Confluence of the Multi-Level Perspective and the Institutional Entrepreneurship Theory: A Case Study of the Phosphorus Transition

Abstract: Humanity faces multiple sustainability issues. Fossil fuels are rapidly diminishing, rising greenhouse gas concentrations greatly threaten the climate, and drinking water is becoming increasingly scarce. Another, less well-known, yet significant issue concerns phosphorus. We could live without cars if petrol ran out, but if phosphorus would run out we would have to live without food. The amount of phosphate-containing fertilizers used has quadrupled in the last 50 years and will continue to rise with the world's growing population. Without the addition of phosphate-based fertilizers, we could only produce food for half of the current world population. Thus, humanity requires a sustainable use of this precious element. Therefore, a transition to a sustainable and circular use of phosphorus is urgently needed.

Several frameworks exist to understand and to guide socio-technical transitions. In this study, a framework will be discussed which combines the multi-level perspective (MLP), which explains the pressures from the niche and landscape

level, with institutional entrepreneurship to clarify the entrepreneurial activities within the regime. The Netherlands, a frontrunner in phosphate recovery, is used as case study. Both pressures from landscape (surplus of phosphates and intensive livestock) and niche level (energy factory) affected the Dutch phosphate regimes. In the early stages, mainly strategic niche management as the congruence of multi-stakeholders took place, followed up by institutional activities as advocacy and enabling work (see episode 3, page 22) to realize the commercialization of struvite via, amongst others, legislative amendments. This shows that the phosphate transition in The Netherlands is a clear example of a confluence of the MLP framework and the institutional entrepreneurship theory. Therefore, we propose to unit these theories to create an overarching framework.

6.1 Introduction

As a result of rising environmental concerns, many scholars have become interested in sustainable transitions.[1] These transitions for sustainable development require functional models to understand and predict behavior and developments, which need to be tested and evaluated by using case studies. An interesting example of a socio-technical transition is the transition towards the sustainable use of phosphorus, which will be used as case study in this article. Phosphorus is a vital resource for sustaining world agriculture and nutrition as it is an essential part of DNA and of molecules required for the energy household of all plants, humans and animals. It is increasingly being realized that current usage of phosphorus is highly unsustainable. Phosphate is retrieved from the soil by crops, which are then consumed by humans or animals. Regeneration of the soil is often disturbed, because i) crop cultivation is in many cases done at a different locus, sometimes even a different continent, than the consumption of plants and/or the animals that eat fodder made from these crops, and ii) animal and human excrements may (therefore) lead to local acidification of the soil and eutrophication of surface waters, while eventually a significant share of phosphates disappear out of the biotic cycle into the oceans.[2] As a response to these problems, wastewater treatment and fertilizer use in the Netherlands are subject of national and European regulations and directives. Simultaneously, phosphorus is increasingly recognized as a scarce resource from a political-economic and security political point of view as phosphate rock is found mainly in a few countries, like Morocco and China.[3] As such, it has become part of EU policies. Due to the strategic dependency of Europe on phosphorus, both phosphate rock as well as the derivative elemental phosphorus are listed in the EU Critical Raw Materials list.[4] Moreover, the global phosphorus use will augment even more in the nearby future

due to the rising population, the increasing (meat) consumption per capita and the growing use of biomass for to enable a bio-based economy.

Phosphate thus pertains to a complex network of interdependent problems. Therefore, in order to guarantee long-term sustainable food production, it is crucial to change the current linear phosphorus system to a circular system. This requires changes in several sectors, including livestock and agriculture, the wastewater and sanitary system, the chemical industry and consumer practices as well. Affected will be the interoperability among the actors; the regulations, legislation, infrastructure and market structure,[5,6] all both at the national and European level. All this contributes to the persistence of the issue.

Given this persistence, it is remarkable that in The Netherlands one solution, namely struvite production, has been realized through several agreements and legislative amendments on precisely such comprehensive changes between government and actors from wildly varying sectoral backgrounds. The objective of this article is to explain how that could occur, also to promote the realisation of a circular phosphorus economy.

In doing so, we will consider the process as part of a *transition* around the (re-)use and processing of phosphate. A transition is defined as "a change from one socio-technical configuration to another".[7] Configurations here refer to a set of coherent, interacting practices and their structural embedment.[8] Through normal processes of structuration, such configurations reproduce each other, lending a significant persistence to the problems they produce.

The central objective of transition studies is to understand how this reproduction may make way for transformation.

A scientifically accepted theory for mapping and analysing such transition dynamics is the multi-level perspective (MLP) theory.[1,9,10] As a heuristic model which, moreover, takes a meta- rather than an actor-perspective, it is too intangible to be used by managers as a tool for realizing systemic innovations.[11] It has therefore been elaborated into a tool called strategic niche management (SNM) with three sensitizing concepts.[12,13] However, SNM has been criticized for still lacking an elaborated agency perspective on how niche experiments may be related to wider systemic innovations and changes in the regime. To understand the roles, influences and tactics of the actors in collaborative undertakings, scholarly work focusing on institutional entrepreneurship may be of help.

Institutional entrepreneurship has been used to describe the entrepreneurial activities to link niche activities to (changes in) the regime or to novel regime elements, so as to establish a social-technical transition.[14,15] The creative and maintaining forms of institutional work described in literature has been included in this study to label the entrepreneurial processes in the Dutch phosphate transition as a case study.[16] We will explore how strategic niche management, as part of the multi-level perspective model, and indicate which elements of institutional entrepreneurship have been crucial to succeed in making struvite a success story in the sustainable phosphorus transition and how the congruence of these two models relates to socio-technical transitions.

6.2 Materials and methods

This research is an exploratory case study which draws upon transition theory, multi-level perspective theory, and institutional entrepreneurship literature for some sensitizing concepts[17] that are specified below in the theory section. Both primary and secondary sources have been used to map and understand the social interaction among the stakeholders involved in the phosphate transition.

Data acquisition

Several types of data sources have been used. Semi-structured interviews with key players of the P transition have been conducted. The interviews focused on the influencers of the process, the barriers, the conditions and if the seven different forms of institutional entrepreneurship (advocacy, defining, mimicry, theorizing, enabling work, mythologizing, embedding and routinizing), played a role in the process. The interviews were conducted between May and October 2018, in Dutch. They typically lasted one hour, and were recorded and subsequently transcribed and cross-validated by the interviewee and/ or a second, independent researcher. Besides interviews, other types of direct communication as phone calls and conferences have been used to obtain and verify information.

A thorough document analysis of primary sources, such as minutes of internal meetings and interviews, and in-company communication documents, as well as secondary, public sources like websites, professional journals, reports of workshops, policy letters, and policy documents have been triangulated with each other and with the conducted interviews to draw a complete picture of the different phases of the transition. The information obtained from the interviews

and secondary data has been used to obtain a good overview of the actions and tactics used during this process and to gain a comprehensive impression of the overall situation and process.

6.3 Theory

The multi-level perspective

The multi-level perspective model (MLP), as proposed by Schot (1988) and Kemp & Rip (1998), and further developed by especially Geels (2002; 2011), is a commonly used framework to map and analyse transition dynamics.[7,9,10,18] Three analytical and heuristic levels are distinguished in the MLP model, and will serve as sensitizing concepts in this study. The dominant configuration of practices and structures is called the *regime*. The regime originates from long-term processes of solving central problems in a particular way. Dominant practices and associated structures (in the form of institutional rules, material infrastructures and dominant discourses and lifestyles) reproduce each other, privileging traditional and constraining and complicating novel practices.[18–20] A transition is a regime change, as a response to novel problems (side effects of regime practices, consequences of exogenous changes) which regime practices are not able to deal with. One source of a transition is instabilities in the regime: internal tensions, disagreements, debates and internal conflicts,[7] which may destabilize a system as we know from neo-institutionalist studies.[21,22] A central theorem in transition theory[8] is that a transition may occur when instabilities and negative feedbacks within the incumbent regime constructively interfere with changes in two other levels.

First, a transition may be promoted by long-term, slow changes in the so-called *landscape*; examples are the politicization of side effects like climate change and eutrophication, individualization, globalization and changing geo-political relations. Such long term trends to exert pressure on regime practices, and (may be mobilized to) lend legitimacy and direction to niche practices. They may also

induce structural change. In all these ways, changes at the landscape level may (be mobilized to) contribute to transitions.

Second, *experimental new practices* may be tried out and tested in the so-called *niches*: areas where they are (partially) shielded off from the sphere of influence of the incumbent regime. A niche allows for out-of-the-box thinking, free from existing (institutional, material and discursive) regime structures; and to protect the innovations from market rejection during the early stages.[10,23] These breeding places for innovations are often a cooperation of different interdisciplinary actors (e.g., users, producers and the government) and facilitated by national subsidies or strategic investments by commercial companies in the form of a pilot study or R&D laboratories. Shaping expectations, network building and learning are the main mechanisms by which a niche may further develop into more mature innovations, together with the structural embedment they need; in the analysis below, we will use them as sensitizing concepts. Thus, they may help shape a more or less rudimentary new regime, based on new and/ or transformed regime elements.[12,24]

Strategic Niche Management

The originators of MLP theory have translated their theory of the constructive interference of changes at the three levels (landscape, regime and niche level) into the strategic niche management (SNM) tool for promoting transitions. Originally, this notion took a bottom up perspective, emphasizing how expanding niches over time would take over the regime. Several scholars criticized this approach for neglecting the degree of stability of regimes (as affected by landscape trends or

intrinsic regime instabilities) as a factor of co-shaping opportunities for transitions.[12,25]

Geels and Schot, recognizing this criticism, have proposed that this bottom-up dynamics is only one out of various possible so-called 'transition pathways'.[26] Based on two dimensions (the nature of landscape changes[27] and the degree of maturity of niches) they have looked into several tens of historical transitions to identify four pathways.[26,27]

1. *Transformation*. In this pathway the developments on a landscape level exert pressure on the regime level, but the niche innovations are not ready and fully developed yet. Incumbent actors will react through adjusting the niche innovations and use the experiences gathered from these modified niche innovations. The experience of the niches can be translated and incorporated into the regime.[1]
2. *Reconfiguration*. In this pathway niche innovations are more developed than in the transformation pathway when the landscape level exerts pressure on the regime. Incumbent regime actors can use niche innovations symbiotic to the existing regime supplementary to the existing technologies to solve specific problems. The adoption of the niche innovations in the regime can change the basic regime structure.
3. *Technological substitution*. Niche innovations are already in a well-developed stage when the pressure from the landscape level occurs on the regime. These niches can break through due to the tensions in the regime as a result of the landscape pressures.
4. *Dealignment and realignment*. This pathway has been characterized by the major landscape pressures, which result in the decomposition of the existing regime, which is called dealignment. This gives an opportunity for the numerous niche innovations to get into the regime level. After a certain period, the best niche innovation will be chosen which will lead to the newly created, stabilized regime (realignment).

As Grin (2008) has argued, turning this more nuanced perspective into full-fledged governance concept requires the introduction of an actor perspective on how to change at the three levels, with respect to each other.[28] While he argues[8,28] that insight in such MLP-based pathways may help to strategically inform contacts, and has pointed to planning literature to elaborate how such connections may be understood as connecting novel practices and structural change, the *work* done by such actors is still ill-understood.[8,28] Here, institutional entrepreneurship literature[15,29,30] may help to develop an analytical framework for our case study.

Institutional entrepreneurship

Institutional entrepreneurship has been introduced in 1988 by DiMaggio as an alternative for the earlier explanation of institutional changes through exogenous shocks.[15] He proposed that institutional entrepreneurs have a prominent role, as catalysts and promotors of structural change by guiding the process in a good direction.[31] This understanding views actors as capable of disengaging from their normal social structure to act as a driver to change their social context, by building new coalitions and lobbying, for example.

More specifically, the *work* done by institutional entrepreneurs has been specified by Boehling, who has identified seven forms of institutional work (advocacy, defining, mimicry, theorizing, enabling work, mythologizing, embedding and routinizing) which can be used by internal institutional entrepreneurs to create the most favourable conditions for innovations.[16] These seven forms, which are the other sensitizing concepts used in this study, are described below in table 1.

Table 1. Forms of institutional work in entrepreneurship processes by Boehling[16]

Forms of institutional work		**Definition**
Creative	Advocacy (Political activities for the creation of institutions)	The mobilization of political and regulatory support through direct and deliberate techniques of social suasion (lobbying, promoting agendas, proposing or attacking legislation)
	Defining (Political activities for the creation of institutions)	The construction of rule systems that confer status or identity, define boundaries of membership or create hierarchies within a field
	Mimicry	Associating new practices with existing sets of taken-for-granted practices, technologies and rules in order to ease adoption
	Theorizing	The development and specification of abstract categories and the elaboration of chains of cause and effect
Maintaining	Enabling work	The creation of rules that facilitate, supplement and support institutions, such as the creation of authorizing agents or diverting resources
	Mythologizing	Preserving the normative underpinnings of an institution by creating and sustaining myths regarding its history
	Embedding and routinizing	Actively infusing the normative foundations of an institution into the participants' day to day routines and organizational practices

The confluence of the two models

In this study, we propose a confluence of the MLP framework with strategic niche management and institutional entrepreneurship. Both adherents of the MLP and the institutional entrepreneurship acknowledge the existence of messy or wicked problems; the conditions necessary to realize the right solution. The multi-level perspective adherents believe that the conditions are established by creating separated incubation rooms, niches, to develop the solution without external

pressures or influences. The 'right' solution is created externally and not in the regime. Institutional entrepreneurship deems that creating the right conditions in the regime is necessary to realize a right solution and institutional entrepreneurs can form these conditions. These entrepreneurs are not 'super heroes', but promoters of new institutional arrangements, which can create an institutional change.[32]

An additional factor, which is insufficiently described in the MLP model, is the possible support of persons working in the regime, the institutional entrepreneurs. Therefore, not only the technical sophistication to compete with the existing technologies is important, but also the power of persuasion to congruence and social adjustment of the different multi-actors from multiple regimes.

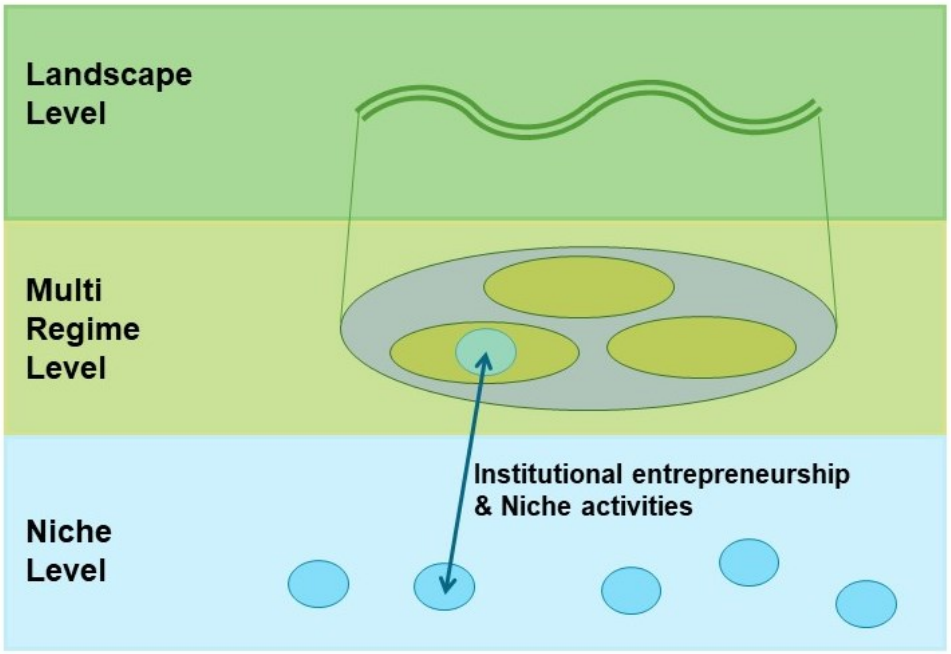

Fig. 1. Visualization of the conceptual model developed in this study; a combination of the multi-level perspective Theory and the institutional entrepreneurship theory.

Our conceptual model, which is a combination of the multi-level perspective theory and the institutional entrepreneurship theory, is described as follows (see also Figure 1). The development of new innovations takes place in incubation rooms, far from the real commercial market, which is visualized as blue dots in the niche level. The market, full of potential institutional entrepreneurs, is not yet interested in these 'not yet ready' innovations. When these innovations have outgrown their incubation room, some institutional entrepreneurs will pick up some elements from these niche innovations which fits their frame of reference and may enable, or promote the upscaling of these niches into the regime level (top down) parallel to niche activities, focused on learning, shaping expectations and network formation (bottom up). This has been visualized by the double arrow connecting the niche with the regime level.

The theory of Geels describes the development of technologies from bottom-up, which can function as starting tool for new innovations by institutional entrepreneurs who will take these innovations into practice.[7] According to Pacheco, institutional entrepreneurs promote new institutional arrangements,[32] which are mainly built and developed in niches and picked up by these promoters/ institutional entrepreneurs. We have checked our conceptual model of the confluence of these two theories using the Dutch phosphate transition as a case study.

6.4 Results

Case of the Dutch phosphate transition

Our case study is situated in the Netherlands, which has a surplus of phosphate in the soil and in surface waters causing eutrophication, which is a serious environmental issue. This phosphate waste problem is a direct consequence of the overuse of fertilizers and having a rather large and intensive livestock sector, which imports most of its fodder from overseas, especially the Americas. Since the challenge to reduce phosphate waste concerning the quality of the Dutch water bodies was politicized some forty years ago, there has been a continuing search for solutions. In spite of this 'landscape trend', phosphate recycling and, hence closing the cycle, has hitherto hardly been realized. The phosphate issue is so persistent, because it is essentially both cross-sectoral and transnational. Yet, in recent years a solution seems to have come within reach. It is rather apparent that one milestone on the road to this success has been the launch of the Dutch Nutrient Platform in 2011, which is a collaborative arrangement of all actors involved.

Several key documents from involved stakeholders and interviews with key players made clear that the initial trigger for the phosphorus transition was the change in mind-set regarding wastewater, which changed from "waste" into "energy" and soon after into "resources".[33–35] To promote a specific solution for the phosphate issue, the Dutch Nutrient Platform was established for phosphate recovery from wastewater by precipitating struvite, which subsequently can be recycled as phosphate fertilizer. In the coming sections, we will discuss in more detail how this collaborative initiative could emerge, how it led to the Nutrient Platform and how the Platform operated to promote a wider, systemic innovation. We will also explore how congruence arose and cross-sectoral collaboration and

action was achieved and how this relates to the MLP and institutional entrepreneurship theory. This phosphorus transition in The Netherlands can be divided into 5 episodes, where the seven different forms of institutional entrepreneurship activities that we observed are highlighted below.

Episode 1 (before 2009): Paradigm shift at water boards: waste to resource (nutrients, energy and water) and finding congruence with other stakeholders

The management and the mind-set of water boards completely changed over the years. Namely, The Netherlands counted 3500 water boards in 1850, 36 in 2004 and 21 in 2018. These mergers changed the water boards from having a regional focus to a much wider focus with strong collaborations, partly through joint institutes and foundations. Important examples are STOWA (a think tank for innovation and sustainability run by water boards, provinces and national government), the Dutch water authorities (the association of the Dutch water boards, in Dutch 'Unie van Waterschappen'), consultancy agencies and several working groups. These overarching foundations facilitated the development of a shared vision and knowledge exchange on three levels, the state, the provinces and the water boards.[33] Moreover, after the amendment of the Dutch water board act in 2007, their management had to be democratically elected, which changed the interaction with society and increased the focus on sustainability due to the public accountability and organisation.[36] The water boards became interlocutors of other governmental bodies (municipalities, provinces and the state) and almost all water bodies became internationally active.[33]

In 2007, the Dutch Water Authorities developed a visionary working group, called WaterWegen, that focuses on identifying the role of water boards in the changing societal environment. The water boards were aware of climate change and

environmental concerns and felt the responsibility to focus on their role and develop sustainable innovation strategies.[33] The working group WaterWegen comprises of volunteering employees of water boards to think out-of-the-box and to change and widen the mind-sets of the water boards. It provides suggestions to the water boards on innovations, which individual water boards then can adopt. In the WaterWegen was the shared belief that innovations work better when experiments are undertaken by a small group and then, when proven successful, are taken up by other water boards. Its aim is not steering, but only facilitating via discussions and information exchange.[34] In MLP terms, WaterWegen may thus be seen as the start of a niche that would provide home to the SNM activities of learning, shaping expectations and network formation.

The energy factory (ef)

Several companies and (semi) public institutes, including the Dutch Water Authorities, have signed an agreement on multiannual energy efficiency (Meerjaren energieefficientieakkoord) to improve their energy efficiency with 30% in 2020 compared to 2005 (2% increase of energy efficiency per year). WaterWegen, organized a contest in 2008 for innovative ideas that will contribute to strengthen the societal position of Dutch Water Authorities. Four individual submissions focused on the same idea: Creating an energy management at the WWTPs to extract energy from wastewater and to realise the energy efficiency goals. The idea of water board Aa en Maas, the energy factory, won the competition. Mid 2008, the four water boards that came to the same idea jointly developed a concept for the realization and implementation of energy factories. Soon after, the energy factory network grew from four water boards to all water boards.[33,37] This development reflected a trend amongst water boards from "waste" to "resource as nutrients,

energy and water", and was the start of a paradigm shift, stimulated by the changing position of the water boards in society.

Next step: The resource factory (gf)

The changing expectations (from being solely treating waste to treating a valuable stream) prepared the common ground for the recovery of valuable resources out of wastewater, making WWTPs a commodity producer. The next step after this paradigm change from only water purging to also energy production (the energy factory) was the start of the extraction of resources, like cellulose and phosphate, by the so-called resource factory (grondstoffenfabriek in Dutch (gf)), which merged in 2011 with the energy factory into the so-called EFGF (energy factory - resource factory).[37] Five water boards were the primary drivers of phosphate recovery at the EFGF: Amstel, Gooi & Vecht (main driver), Aa & Maas, Drents Overijsselse Delta, De Dommel, Rijn & IJssel, and Vallei & Veluwe.[38]

Episode 2 (2009): Establishing congruence between all stakeholders

While the EFGF was a joint undertaking between several water boards, they differed amongst each other in terms of their precise interests regarding phosphate recovery. For some water boards, P recovery primarily meant a way to improve the surface water quality, while others appreciated it as a way to resolve the surplus of phosphate due to the excess of manure. These differences were largely related to the differences in conditions between regions. Interestingly, the direct trigger for innovation was when some water boards were directly facing the problem that a type of phosphate containing material, struvite, was clogging the pipelines. These boards started to explore the possibilities to recover the phosphate via struvite (on purpose) from communal wastewater to reduce the maintenance costs. More precisely, this initiative was taken by Water Board Rijn en IJssel in 2006 in

collaboration with a potato processor to deal with the latter's wastewater by producing struvite. This initiative to develop a struvite precipitator was born, and was followed later by several water boards at communal wastewater treatment plants. As first, Amstel, Gooi & Vecht (2013) and soon after also Reest en Wieden (2013), and Aa en Maas and Vallei en Veluwe (2015) started producing struvite.[39]

The Dutch Water Authorities was well aware of its frontrunner position, as indicated by the director in 2014. "*Our motto is recovering everything valuable. This is completely new and therefore pioneering work. There is a lot of interest from knowledge institutes and companies. We need this cooperation. To supply the technology and to get an outlet market of the recycled products*. (Peter Glas)."[40] Therefore, the Dutch Water Authorities nurtured, offering STOWA as a platform for mutual learning between these pioneering water boards within the niche. Typical for a learning process in niche experiments, it involved both developing the needed knowledge and technology, and defining the changes in the role, tasks and responsibilities of water boards implied in the initiative. This included the novel societal position of wastewater treatment plants (WWTPs) that now also became supplying actors in the phosphate market.

Several of these water boards had already been collaborating with each other, under auspices of the Dutch Water Authorities, on recovering energy, and as they had found out the systemic nature of the innovation, it did not take long for them to start to collaborate on the phosphate recovery through struvite as well. They benefitted from the STOWA as a platform for knowledge development and problem solving.

As we have seen, any solution to the phosphate issue essentially requires collaboration with other sectors, such as the agriculture industry, engineering companies and the chemical industry. Therefore, water boards started to enrol actors from these sectors by involving them in several workshops and meetings (network formation).

In May 2009, STOWA and engineering company Sweco invited companies from up- and downstream the phosphate flows, as well as engineers from various backgrounds. However, eventually, mainly participants from the wastewater sector attended, due to cancellations from agricultural actors – apparently reflecting a difference in interest between the wastewater and the agricultural sector. In this workshop, several lectures where held concerning phosphorus scarcity. The participants of the workshop discovered that, while they differed in their precise problems definitions regarding phosphates, they could agree on a solution strategy (recycling phosphate through the struvite route) that made sense to all of them. They concluded that all actors responsible for water management (water boards, provinces, municipalities, department of waterways and public works and drinking water processors) would have to work together. Moreover, they concluded that it was desirable to have one organisation which is committed to dealing with the combined phosphate problem of both the water boards and the agricultural sector, which could have been the start of the Nutrient Platform.[41] Unfortunately, hitherto they had not managed to include actors from agriculture in the learning process and network.

Following this workshop, other meetings were organized under auspices of the Dutch Water Authorities to bring all stakeholders together. The Dutch Water

Authorities acted as institutional entrepreneurs via framing new innovations and tactics as solutions to their respective problems, and made the framing for each actor appealing to the other stakeholders. The other stakeholders started to understand the bigger picture of how the struvite route started to represent congruence between them, as it provided solutions to their respective problems.

To start with, workshops and group interviews, organised by WaterWegen on behalf of the Dutch Water Authorities in February 2010, made different fields familiar with each other's interests and visions. One of the main outcomes of these workshops was the definition and creation of a shared vision, which was afterwards discussed with the water board administrators and slightly fine-tuned.[42] Subsequently, the expectations were translated into 'vision pillars' and presented to the administrators of the involved water companies. On one proposed vision, the production of resources, energy and water, all the administrators of the water boards unanimously agreed, which shows the joint vision on the production of resources.[42] During these workshops, the participants had set goals for the water boards for phosphate recovery of >60% (2020) and >90% (2030) reuse of phosphate as a fertiliser ingredient for a competitive price. There was a joint belief that individual responsibilities should be less strict and more diffuse, as long as there was a common consensus to reach the shared targets. This shows that the water boards were looking beyond their main tasks and problems, seeking to deal with the phosphate problem in collaboration with new partners. Still remaining to be done was to achieve congruency with the needs of industries (other than the potato processor) and the agricultural sector. A key step toward this goal was the establishment of the Nutrient Platform, which not only broadened the network but – by operating at arm's lengths distance from government – would also help

achieve congruency with the not yet involved stakeholders from outside the water industry.

Episode 3: Establishment of the Nutrient Platform, multi stakeholder congruence and signing the Dutch value chain agreement

Parallel to the adoption by the water boards of a broadened understanding of their mission, the nutrient flow task group (NFTG) emerged, started by the Dutch water partnership (NWP) including the involvement of several other organisations, initially to put P depletion (in developing countries) on the agenda. The NFTG started in October 2009 as a collaboration with TA Steering committee, an independent working group of the Dutch Ministry of Agriculture, Nature and Food Quality, which labelled P scarcity as an important theme for the Netherlands. The NFTG was a subsidized project, but by the end of the subsidy period the involved organizations noticed that they had developed a rather fruitful collaboration that they might as well extend to the entire county of The Netherlands. They desired a structural driver/secretary on this topic; the idea to start a Nutrient Platform was born.

On 13 January 2011, the Dutch Nutrient Platform was established on the initiative of eight founders, the parties within the NFTG group (Aqua for all, GMB, Grontmij, SNB, Thermphos, WASTE & WUR, together with NWP), from different sectors: companies, knowledge institutes, NGOs. The platform was set up as an intermediary, connecting multiple actors from waste processors, agriculture, sanitation industry, fertiliser industry, NGOs, scientific communities and the government, into a network. To show the individual willingness and commitment, the members, at that time already 19, of the Nutrient Platform financed the

position of Nutrient Platform Secretary, which also showed mutual commitment and believe.

The Nutrient Platform wanted to clarify the individual, vested interests to speed up the process in a value chain agreement. One of its aims was to develop a solid business case for the recycling of phosphates throughout the whole value chain, e.g. in the form of struvite, and a mature European market for recycled nutrients. Its first achievement as institutional entrepreneur was formulating and concluding the so-called the value chain agreement on the phosphate cycle (in Dutch: ketenakkoord fosfaatkringloop) **[defining]**.

The Dutch ministries played a strong, facilitating role within the process toward that success, through positioning one proactive, entrepreneurial civil servant, as a 'value chain director', the driver of the Nutrient Platform. This value chain director brought together several companies and ministries, using the announcement that the State secretary of Infrastructure and Water Management, also on behalf of the Ministry of Economic Affairs and Climate Policy, would sign to present the others an offer they could not refuse **[enabling work, mythologizing]**. He also brought in the Dutch Water Authorities, which thus got involved in the platform. Also, he organized several workshops with governmental representatives and selected partners to prepare the value chain agreement. Soon after the launch of the platform, on 4 October 2011, the value chain agreement was indeed signed by the State secretary, Nutrient Platform and 19 partners **[defining]**. It stated that the common ambition and intentions of the national government of The Netherlands in cooperation with multiple parties was the creation of a sustainable market for recovered phosphates.[43] The partners showed that they were willing to invest in

joint processes, on the basis of a shared long-term vision: to close the phosphate cycle via an action plan to stimulate nutrient recycling with legislation.

The focus of the Nutrient Platform was regional, national and European. Since the Netherlands had a surplus of phosphates, the focus on Europe was well justified as a potential area of distribution of the secondary phosphates. This has also been a driver for the ministries to finance the European conference in 2013 in Brussels, which was the first step of the European Phosphorus Platform, established by the value chain director of Nutrient Platform, the institutional entrepreneur, to spread the knowledge gathered at national level to the European level.

Episode 4: Dealing with legal and institutional constrains

The jurisdiction of the tasks of water boards appeared to be a hurdle for the implementation of phosphate recovery technologies at WWTPs. Historically, the main goal of water boards as public bodies is the treatment of wastewater. It was thus not evident that water boards had the legal competence to recover resources and commercialize (!) these. A study, published by STOWA in 2012, concluded that energy production for own use fits within the tasks of a water board, namely purging of waste water, but the production of valuable, commercial resources could be only possible if this is stated in a new law amendment.[44]

While this led to a lot of questions and doubts within the water sector, it did not stop the sector from evolving, and new legal solutions were explored **[enabling work]**. In 2014, STOWA and the Dutch Water Authorities commissioned a study on the juridical constraints of wastewater treatment plants.[45] The authors concluded that WWTPs can recover valuable products, as long as it is in line with the execution of the juridical tasks of the water board, in this case the treatment of

waste water. A letter by the Minister,[46] upon an inquiry by the Dutch Water Authorities, had stipulated that as long as it does not infringe the EU competition regulations, the recovered products could be sold for market-conform prices **[advocacy]**.[45] In the case of struvite, which is intentionally used to reduce the maintenance costs of wastewater treatment, this is in line with their legal tasks.[45] Nevertheless, there were still juridical challenges for the Dutch wastewater treatment plants that are recovering phosphate as struvite to be used as a slow release fertilizer. Due to its origin, mainly municipal wastewater, struvite was seen as waste and the fertiliser act prohibits the use of waste as fertilizers.

Episode 5: Amendment of the Dutch Fertiliser Act

In November 2014, the Unie van Waterschappen organized a congress where a Green Deal (an agreement between national government and a set of actors to undertake sustainability action) was concluded. This Green Deal "grondstoffen waterschappen", for which the way had been paved by an earlier (2011) Green Deal **[mimicry]** on the acceleration of the extraction of sustainable energy from wastewater, which has been realized through lobbying of the Dutch Water Authorities for the energy factory **[advocacy]**, focuses on the recovery of valuable resources from wastewater and sludge. It was signed by the Ministry of Infrastructure and Environment, the Ministry of Economic Affairs, the Dutch Water Authorities and STOWA **[defining]**. This shows that the Dutch government was willing to facilitate and endeavour practical solutions for the current juridical hurdles on the commercialization of struvite.[35]

On December 16, 2015, the Nutrient Platform and the EFGF, collaboratively organized a meeting with seven members of the Dutch Parliament, to inform them about success stories and advice them about phosphate recycling and the actions

which had to be taken before the discussion of the house of representatives on phosphate **[advocacy]**.[47]

One of the first results of the green deal was the amendment in the rulings of the Dutch Fertiliser Act (in Dutch: Uitvoeringsbesluit meststoffenwet) **[advocacy]**. Only struvite derived from the potato industry was included in the fertiliser act, therefore using struvite from other phosphate rich sources (e.g., a WWTP) as a fertiliser was still prohibited and had to be requested, reviewed and included for each struvite producer individually, before it could be used as a fertiliser. Since 2013, struvite was produced at several WWTPs, but this struvite could not be sold as a fertiliser yet. As an employee of Vallei en Veluwe mentioned after the launch of their struvite precipitator (2015) that regulatory adaptions are necessary: "To exploit all opportunities, legislation has to be softened. The perspective of wastewater has been changed. Wastewater is a source of sustainable energy & resources which demands regulatory changes."[48] After intensive lobbying from the Dutch Water Authorities, EFGF and the Nutrient Platform, the Ministry of Economic Affairs and Climate Policy started a notion on struvite and counselled the WUR and NMI for advice on the possibility to include struvite into the Dutch Fertiliser Act and on the prerequisites of the products **[enabling work]**.[49] The WUR and NMI conducted several interviews with stakeholders, and found out that the end-of-waste status of struvite and the lack of legal instruments to allow the use of struvite as a fertiliser was considered by the Dutch industry hampering the use of struvite in agriculture.[50] There was a demand from the industry for a generic regulation concerning all types of struvite. The government adapted the Dutch Fertiliser Act accordingly after the lobbying of the Nutrient Platform representing its members. Struvite can be traded in the Netherlands since 2015,

due to this amendment and so inclusion of struvite as a fertiliser in the Netherlands under certain conditions. A clear example of the tactic lobbying of institutional entrepreneurs to change the political environment in favour of their goal **[advocacy]**.

Now the national regulation has been changed, still struvite could be exported across borders. Therefore, Amsterdam, Gooi & Vecht (a water board), Aquaminerals and the French water companies Suez and Veolia initiated the inclusion of struvite as a case in the International Green Deal North Sea Resources Roundabout (an initiative of The Netherlands, France and Belgian Flanders) to make the first step towards the creation of a European struvite market via opening up cross-border trade.

Some water boards decided to not become a commodity trader of struvite themselves. Aquaminerals, established in 1995, was the trader of secondary raw materials of the drinking water industry. Since January 2018, the water board Aa & Maas, became a stakeholder as the first water board and wastewater processor part of Aquaminerals to outsource the trading aspect. Aquaminerals uses its experience in trading of secondary resources from the drinking water industry, to trade the recovered phosphate products. This solves the trading issue and concerns of the water boards. Other water boards use different constructions, as implementing an Ostara technology, which has a lease construction of the technology and the owner of the technology will be the seller of the struvite as well **[enabling work]**. Others sell their struvite themselves to fertilizer companies. The focus is now instead of only water, on energy, nutrients and other valuable products as high in the value pyramid as possible as well. The water boards position themselves as proactive,

entrepreneurial public entities and use their position in the water value chain to work on societal challenges.

6.5 Discussion and conclusion

Several factors can have an impact on the socio-technical regime; the innovations within the niche level and the changes at the landscape level. Both factors play a role in this case study. Environmental changes at the landscape level, such as the surplus of phosphates in the Dutch soils, eutrophication of the lakes, the change of culture within water authorities, and political issues as the uncertainty and dependency of resources leading to the inclusion of phosphate rock into the European critical raw materials list, cause a slow, creeping but continuing change at the landscape level. On the other hand, niches as the energy factory and later the resource factory put pressure on the regime level as well. Due to the excess on the one hand and the political dependency on the other hand, the government has put phosphate on the agenda, the farmers have to adapt their common practices regarding fertiliser use and the WWTPs can implement phosphate removal technologies to avoid leaching of phosphates without legal hurdles.

The Nutrient Platform is a clear example of a bottom up (the need and commitment from the companies in the NFTG – niche level) in combination with a top down approach (the financial and in-kind aid of the Ministry – regime level). The government was able to take the lead via the value chain director at the Nutrient Platform and the willingness to invest in different stages and develop a long-term strategic vision, as financing the start of the European sustainable phosphorus platform established by the Nutrient Platform. With the Nutrient Platform, and later the European sustainable phosphorus platform initiated by the Nutrient Platform, an identity was created which was represented by a

spokesperson. This sealed the intense cooperation among the several institutional entrepreneurs.

The five episodes of the Dutch phosphate transition can be divided into two trajectories. In the first, mainly strategic niche management, focused on learning, shaping expectations and network formation, took place. This yields, in the first two episodes – and partly episode 3 – the construction of multi-stakeholder governance and congruence, and thus alignment of the technical aspect with the social political aspect. Episode 1 focuses on the social network analysis and the analysis of expectations of the involved stakeholders. The Dutch Water Authorities encourages the paradox of embedded agency with its working group WaterWegen, actors that are stimulated to impose a change of the institutions, the water boards where they are working for, collaboratively. It started with a paradigm shift at water authorities concerning their role in society, from purging water to energy producer to resource producer. The Dutch Water Authorities and the founders of the Nutrient Platform noticed in parallel that the phosphate transition could only be realized by including all the multiple stakeholders for semi-coordinated action and establishing mutual congruence. Due to the cooperation and collective actions, initiated by the water boards and other companies and partners itself, a shared believe, vision and mutual commitment was established and created. Via building up the approach of, the at first niche idea, the energy factory, the Dutch Water Authorities and the four involved water boards were setting the standards for the other water boards on this topic. During workshops and conferences, the involved partners were beyond their main tasks and problems and tried to solve the main problem together without infringing their goals.

In the third episode, a multi-stakeholders governance brought all actors from diverse sectors and social spheres, such as the water authorities, fertilizer industry, governmental bodies, NGOs, scientific communities together with the mean to create a cross-sectoral, multi-stakeholders alliance with vested interests concerning the phosphate problem. This paved the way for the second trajectory in which institutional entrepreneurship became the dominant activity.

In episode 3, one resource-full actor, with a strong network in both the governmental bodies and the private partners, showed strong entrepreneurial activities. He brought these cross-sectorial stakeholders together and via strong advocacy enabled the first standardization of set regulations and agreements under the aegis of the Nutrient Platform. This shows strong advocacy and defining forms for the creation of the new form of institutional work. In doing so, he could draw on the legitimacy yielded by the promises of the joint solution on the one hand, and on the other hand the commitment from the government implied in the value chain agreement. Similarly, the advocacy from the Nutrient Platform led to the amendment of national legislation that facilitate the commercialization of struvite as fertilizer and collaboration between institutes - facilitating the new P recovery trend among the involved institutions. Also, new formal rules were negotiated on the basis of which water boards could trade resources; and a distribution company was hired to take over the commercialization of the struvite.

Even the legal and institutional constrains did not stop the institutional entrepreneurs, through lobbying, they solved the two main juridical challenges. The first challenge was the question if producing secondary commercial products fitted in the role of water boards as a public organ. The Nutrient Platform and the

Dutch Water Authorities had contact with several stakeholders including the government, which resulted in a confirmation of the minister that the water boards could produce struvite. The second juridical hurdle was the waste label of struvite, which hindered the commercialization of the product. This hurdle was tackled after the Nutrient Platform lobbied at the ministries in the name of all involved partners.

In short, both pressures from landscape and niche level affected the Dutch phosphate regimes. In the early stages, mainly strategic niche management as the congruence of stakeholders took place, followed up by institutional activities as advocacy and enabling work from episode 3. This shows that the phosphate transition is a clear example of a confluence of the MLP framework and the institutional entrepreneurship theory.

6.6 References

[1] A. Smith, J.-P. Voß, J. Grin, *Res. Policy* **2010**, *39*, 435–448.

[2] M. M. Mekonnen, A. Y. Hoekstra, *Water Resour. Res.* **2018**, *54*, 345–358.

[3] M. De Ridder, S. De Jong, J. Polchar, S. Lingemann, *Risks and Opportunities in the Global Phosphate Rock Market*, The Hague, **2012**.

[4] "Communication from the commission to the European parliament, the council, the European Economic and social committee and the committee of the regions on the 2017 list of Critical Raw Materials for the EU," can be found under http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52017DC0490&from=EN, **2017**.

[5] T. Nesme, P. J. A. Withers, *Nutr. Cycl. Agroecosystems* **2016**, *104*, 259–264.

[6] J. Grin, in *Well-Being, Sustain. Soc. Dev. Netherlands 1850-2050* (Eds.: H. Lintsen, F. Veraart, J.-P. Smits, J. Grin), Springer Publishers, Heidelberg, **2018**.

[7] F. W. Geels, *Res. Policy* **2002**, *31*, 1257–1274.

[8] J. Grin, J. Rotmans, J. W. Schot, *Transitions to Sustainable Development : New Directions in the Study of Long Term Transformative Change*, Routledge, **2010**.

[9] A. Rip, R. P. M. Kemp, R. Kemp, *Technological Change*, Battelle Press, Columbus, Ohio, **1998**.

[10] J. Schot, *Hist. Technol.* **1998**, *14*, 173–200.

[11] M. C. J. Caniëls, H. A. Romijn, *Learn. Organ.* **2008**, *15*, 336–353.

[12] R. Hoogma, R. Kemp, J. Schot, B. Truffer, *Experimenting for Sustainable Transport : The Approach of Strategic Niche Management*, Spon Press, London, **2002**.

[13] J. C. C. M. Huijben, E. B. A. van der Vleuten, R. P. J. M. Raven, G. P. J. Verbong, *Implementation Strategies for Desert Solar Power Plants : Strategic Niche Management, Social Acceptance, and Business Models*, Routledge Taylor & Francis Group, Oxford, **2012**.

[14] R. J. A. Klein Woolthuis, *Sustainability* **2010**, *2*, 505–523.

[15] P. Dimaggio, **1988**.

[16] K. Boehling, in *6. Organ. Stud. Summer Work.*, **2011**, pp. 1–26.

[17] H. Blumer, *Symbolic Interactionism : Perspective and Method*, University Of California Press, **1986**.

[18] F. W. Geels, *Environ. Innov. Soc. Transitions* **2011**, *1*, 24–40.

[19] J. Grin, F. Felix, B. Bos, S. Spoelstra, *Int. J. Foresight Innov. Policy* **2004**, *1*, 126–149.

[20] B. Bos, J. Grin, *Sci. Technol. Human Values* **2008**, *33*, 480–507.

[21] A. J. Hoffman, *Acad. Manag. J.* **1999**, *42*, 351–371.

[22] M.-G. Seo, W. E. D. Creed, *Acad. Manag. Rev.* **2002**, *27*, 222.

[23] F. W. Geels, *Res. Policy* **2004**, *33*, 897–920.

[24] J. Schot, F. W. Geels, *Technol. Anal. Strateg. Manag.* **2008**, *20*, 537–554.

[25] R. P. J. M. Raven, Strategic Niche Management for Biomass, Technische Universiteit Eindhoven, **2005**.

[26] F. W. Geels, J. Schot, *Res. Policy* **2007**, *36*, 399–417.

[27] H. Van Driel, J. W. Schot, *Technol. Cult.* **2005**, *46*, 51–76.

[28] J. Grin, in *Manag. Transit. to Renew. Energy Theory Pract. from Local, Reg. Macro Perspect.* (Eds.: J.C.J.M. Van den Bergh, F.R. Bruinsma), Edward Elgar, Cheltenham, **2008**, p. 385.

[29] R. Garud, P. Karnøe, *Res. Policy* **2003**, *32*, 277–300.

[30] J. Battilana, B. Leca, E. Boxenbaum, *Acad. Manag. Ann.* **2009**, *3*, 65–107.

[31] P. Colomy, G. Rhoades, *Sociol. Perspect.* **1994**, *37*, 547–583.

[32] D. F. Pacheco, J. G. York, T. J. Dean, S. D. Sarasvathy, *J. Manage.* **2010**, *36*, 974–1010.

[33] Unie van Waterschappen, "WaterWegen Visie op rol en positie van waterschappen in de nabije toekomst," can be found under http://www.watererfgoed.nl/links/waterwegen.pdf.

[34] WaterWegen, "LEF. Anders denken, anders doen," can be found under http://waterwegen.org/wp-content/uploads/2018/04/LEF-document.pdf,.

[35] "C-174 Green Deal Grondstoffen Unie van Waterschappen - Rijk," can be found under https://www.greendeals.nl/sites/default/files/downloads/GD174-Grondstoffen-UvW-Rijk.pdf.

[36] T. K. der Staten-Generaal, "Wijziging van de Waterschapswet tot het invoeren van de verkiezing van de vertegenwoordigers voor de ingezetenen in het algemeen bestuur van het waterschap door de leden van de gemeenteraden; Memorie van toelichting," can be found under https://zoek.officielebekendmakingen.nl/kst-33097-3.html.

[37] "Hoe is EFGF ontstaan? | Energie en Grondstoffen Fabriek," can be found under https://www.efgf.nl/facts-en-figures/hoe-is-efgf-ontstaan/.

[38] "Top 5 grondstoffen EFGF," can be found under https://www.efgf.nl/uploads/editor/TOP5_TREKKERS.pdf.

[39] STOWA, *Verkenning van de Kwaliteit van Struviet Uit de Communale Afvalwaterketen*, **2015**.

[40] "Green Deal Grondstoffen getekend | Energie en Grondstoffen Fabriek," can be found under https://www.efgf.nl/actueel/green-deal-grondstoffen-getekend/.

[41] STOWA, *Fosfaat, van Leegloop Naar Kringloop*, **2010**.

[42] B. Römgens, E. Kruizinga, *Voorstudierapport Afvalwaterketen*, **2011**.

[43] Nutrient platform, "Ketenakkoord Fosfaatkringloop," can be found under https://www.uvw.nl/wp-content/uploads/2011/10/Ketenakkoord-Fosfaatkringloop-2011.pdf, **2011**.

[44] A. Gerbrandy, R. Nehmelman, H. van Rijkswick, T. Verstappen, S. de Vries, *Innovatie En Duurzaamheid: Valorisatie van Afvalwater*, **2012**.

[45] M. I. S. Sloover, M. K. Klootwijk, *Juridische Handreiking Duurzame Energie En Grondstoffen Waterschappen*, **2014**.

[46] "Vaststelling van de begrotingsstaat van het Deltafonds voor het jaar 2013 ; Brief van de minister van infratructuur en milieu," can be found under https://zoek.officielebekendmakingen.nl/kst-33400-J-19.html.

[47] "Het uur P: in gesprek met Tweede Kamerleden | Energie en Grondstoffen Fabriek," can be found under https://www.efgf.nl/actueel/het-uur-p-in-gesprek-met-tweede-kamerleden/,.

[48] "Eerste fabriek voor kunstmest uit afvalwater geopend | Energie en Grondstoffen Fabriek," can be found under https://www.efgf.nl/actueel/eerste-fabriek-voor-kunstmest-uit-afvalwater-geopend/.

[49] G. Twynstra, *Notitie. Energie- En Grondstoffenfabriek.*, **2014**.

[50] P. A. I. Ehlert, T. A. van Dijk, O. Oenema, *Opname van Struviet Als Categorie in Het Uitvoeringsbesluit Meststoffenwet*, **2016**.