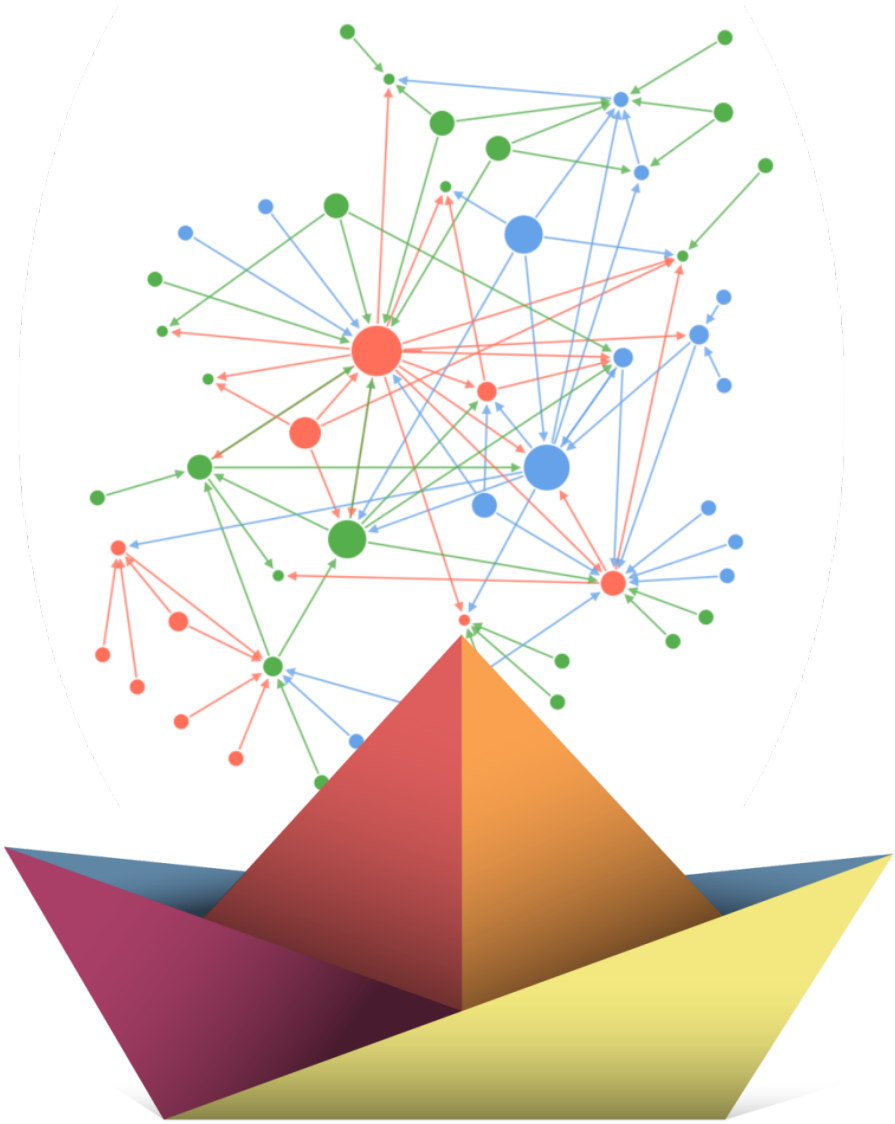
Strengthening the knowledge-action system of circular and sustainable water governance in Amsterdam

C. van Splunter



Strengthening the knowledge-action system of circular and sustainable water governance in Amsterdam

C. van Splunter

(student nr. 2521543)

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VU-Supervisor: Dr. Renée de Wildt-Liesveld (VU University)

On-site supervisor: Dr. Laurens Hessels (KWR)

Executive summary

To prevent catastrophic events (e.g. floods and water scarcity), it is crucial that the water management of a city can anticipate adequately to future challenges (e.g. climate change and urbanization). It is therefore important to learn from, and experiment with new techniques, collaborations and different forms of governance. Multi-level collaboration and understanding is needed from all actors involved (research, practice and, policy and management). Unfortunately, it often happens that actors have different interests, visions and goals, which may lead to disconnection between actor groups. Because of this, generated knowledge often does not sufficiently find its way into policy, which prevents easy adaptation by the water management system. Improving the Knowledge Action System (KAS) is therefore an important issue for circular and sustainable water governance in Amsterdam. A KAS is described by the networks of actors involved in the production, sharing and use of all policy relevant knowledge.

Little was known about the current performance and appearance of the KAS within the Amsterdam water governance. Moreover, it was unclear if, and in what way KAS could be improved. Therefore, the aim of this study was to investigate how the KAS of circular and sustainable water governance in Amsterdam could be improved. The following main research question (RQ) is formulated: *How to improve the KAS of circular and sustainable water management in Amsterdam?*

In this study, a conceptual model was designed based on the KASA framework and the action research spiral. The conceptual model resulted in two sub-research questions (SRQ):

1. *How does the current KAS function and what bottlenecks or opportunities can be identified?*
2. *What are effective actions that could improve and stimulate the KAS?*

To find opportunities and bottlenecks of the current KAS (SRQ1) the KASA framework was used. The model assessed the KAS based on five concepts: diversity and inclusion, connectivity, position and power, visions and boundary assessment. The action research spiral was used to find effective actions for KAS improvement (SRQ2).

An explorative action research was conducted in two sequential phases each answering one of the SRQs. To answer SRQ1, in phase 1, 30 semi structured interviews and a survey (33 respondents) were used. Respondents were actors from practice, research and, policy and management situated in the KAS. Interviews were transcribed and analyzed by using codes from the conceptual model. To answer SRQ2, in phase 2, actions were devised based on the KAS assessment (phase 1), and performed in an existing program ('Innovation in Watergovernance' program) to improve the KAS. Reflection on the actions was done by multiple methods as a questionnaire, oral feedback from participants, and keeping a log with records and a portfolio with relevant materials.

From this study, there is reason to assume that the current KAS of circular and sustainable water management in Amsterdam does function properly. Based on the assessment many positive features (opportunities) were found. The KAS consisted of a high level of knowledge and valuable actors. Furthermore, the boundary between research and implementation is decreasing (in practice and policy domains), which helps to develop valuable and applicable knowledge. The vision of circular and sustainable cities was generally shared among all actors in the KAS, which helps creating a feeling of working towards a common goal and hereby stimulating network relationships.

Despite the positive features, the KAS did face some limitations (bottlenecks). It was found that within the KAS certain knowledge types (economic knowledge and legal knowledge) and actors (users and

actors from the energy sector) were underrepresented. Consequently, implementation of knowledge was inhibited. Another bottleneck was the poor capturing of generated knowledge within policy and practice domains, hereby, many valuable generated knowledge is lost for the KAS. A lack of a clear overview of actors involved and where knowledge is situated in the KAS was also a bottleneck for the KAS. It is unclear for actors where to find the right knowledge and thus, miss out on knowledge. This indicates a better overview can improve the connectivity of the KAS. Competition between and within actors from practice and policy also led to actors missing out on knowledge due to concealment of knowledge. The connection between research and practice was found to be poor and could be improved. A better connection could lead to more valuable knowledge from research for other domains in the KAS.

Actions were devised to improve three identified targets (based on the assessment): improve network diversity, strengthen network relations and strengthen knowledge exchange. The conducted actions were: 'Knowledge Workshops' (in world café setting), an internet page and a LinkedIn group. Knowledge Workshops were very helpful for improving all three targets. Network diversity was improved by creating new relations between participants. The sense of togetherness and the ability to share visions and perspectives helped to connect and strengthen network relations. Knowledge Workshops were also useful for stimulating knowledge exchange. It was found that both digital platforms were not optimal for strengthening network relations, however, the website did have potential for providing helpful clear visualizations and overviews of the network. The website did have potential for strengthening knowledge exchange. The LinkedIn group was not useful for strengthening knowledge exchange. Members were rather passive users of the LinkedIn platform and therefore also passive users of the 'Innovation in Watergovernance' group. It was unclear whether the LinkedIn group was useful for improving network diversity.

In conclusion, to improve the KAS of circular and sustainable watergovernance in Amsterdam, finding out positive and negative features of the KAS was found useful. Based on this, opportunities and bottlenecks of the KAS were identified on which further actions could be taken. Improvement of the KAS was done by performing actions in practice. Knowledge Workshops were highly valuable for improving the KAS. Digital platforms were useful as support for the KAS. It helped to make the network more visible and clear. It is concluded that, by performing the targeted actions, the identified bottlenecks of the KAS can be improved which may lead to an overall improvement of the KAS.

The present study did build further on the concept of KAS. It provided insights into how the concept can be applied to a sector which is working towards transition. Furthermore, the KASA in this study was used to find opportunities and bottlenecks of the KAS and did apply practices for improvement, what is not yet done before. The study furthermore contributed to a better understanding of the current circular and sustainable watergovernance in Amsterdam. It provided insights into the relations within this sector between different actors from all fields and the corresponding features with regards to knowledge. This study directly helped by reaching out to all actors involved and highlighted the importance to them for collaboration while managing the transition.

To further improve this KAS, the action research can be expanded into more actions (within the 'Innovation in Watergovernance' program). The action research in the present study was far from comprehensive and therefore better and more efficient methods may be found. It is moreover valuable to explore and further develop the concept of KAS. Therefore, more research is needed that applies the KASA in different contexts facing a challenge, such as technical innovation management in the health care sector.

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1. Introduction

The water management sectors of most cities worldwide are currently facing many challenges. For instance, rapid urbanization, climate change, inadequate maintenance of water and infrastructures and poor wastewater management can lead to catastrophic consequences such as floods, water scarcity, water pollution, adverse health effects and high rehabilitation costs for cities (Koop & Van Leeuwen, 2016; Van der Brugge, Rotmans, & Loorbach, 2005). For this reason, it is crucial that water management is able to anticipate adequately on future challenges (Koop & Van Leeuwen, 2016; Van der Brugge et al., 2005). In line with this, Roest et al., (2016) stated that it is important to promote the current trend of moving towards a circular and sustainable water cycle.

For this, it is important to learn from, and experiment with new techniques, collaborations and different forms of governance. Unfortunately, it often happens that researchers, actors from practice and policy-makers have different interests, visions and goals, something which may lead to situations in which the connection between these three actor groups is lost or even absent (Crow-Miller, Chang, Stoker, & Wentz, 2016; Edelenbos, van Buuren, & van Schie, 2011; Ison et al., 2011). Because of this, newly generated knowledge (both scientific and practical) often does not sufficiently finds its way into policy (Campbell et al., 2009; Crow-Miller et al., 2016). Moreover, policy-makers are not always able to respond properly to the knowledge presented by researchers and actors from practice (Dobbins, Rosenbaum, Plews, Law, & Fysh, 2007). This prevents an easy adaptation by the water management system to upcoming trends. The Dutch Water board Amstel, Gooi en Vecht (AGV) is very much aware of possible limitations in this network of actors, the so-called knowledge-action system (KAS), that may affect its water governance (Dijk & Meertens, 2015).

A KAS is described as the networks of actors that are involved in the production, sharing and use of policy-relevant knowledge (Munoz-Erickson, 2014). To have best policy, an ideal policy triangle of actors should be present (Ison et al., 2011). This triangle consists of researchers, practitioners/entrepreneurs and policymakers, each contributing to policy. Researchers provide scientific knowledge, entrepreneurs provide the more practice-knowledge (local and generic) and policymakers are the ones that make decisions and create policy (Munoz-Erickson & Cutts, 2016). During this policy creation process, policymakers can use knowledge generated by the other actors, but also drag in their own interests and the political context.

In view of the above, improving the KAS is an important issue for water governance in Amsterdam, especially within the context of circular and sustainable water management. Limitations in the KAS are worrisome for policymakers, since they may lead to problematic situations such as being disconnected from practice and research and being overtaken by other trends and institutions (e.g. local initiatives that start to apply decentralized water treatment (Roest et al., 2016; Samuel et al., 2016)).

Water Board AGV is therefore interested in finding opportunities for improvement of the KAS. Unfortunately, little is known about the current performance and appearance of the KAS within the Amsterdam water governance structure. Moreover, although policymakers and researchers operating in this water sector with a focus on a circular and sustainable way of water management in Amsterdam mention that they want to collaborate with each other and other stakeholders (e.g. citizens, local research initiatives and entrepreneurs) to improve the KAS, they do not have a readymade approach yet. Insights into current performance of the KAS (Munoz-Erickson, 2014) and into effective and suitable tools and methods to perform good knowledge coproduction (Crow-Miller et al., 2016) are needed to improve the KAS.

Water Board AGV, together with the KWR water cycle research institute and other research institutions therefore initiated a programme entitled ‘Innovation in Watergovernance’, a three- year, action-

oriented, reflexive and trans-disciplinary research programme (see chapter 2.3). Within this programme, special attention is paid to the KAS. The current study is part of the programme and focuses on improving the KAS.

1.1 Objective and Research question

The main objective of the current study is to provide recommendations that could contribute to an improved ability of the Amsterdam water sector to respond adequately to future challenges and trends by improving the KAS with respect to water governance in the region of Amsterdam. This was done by investigating how the KAS of circular and sustainable water governance in Amsterdam could be improved and at the same by actual intervention to improve it.

We formulated the following main research question:

How to improve the KAS of circular and sustainable water governance in Amsterdam?

2. Contextual Background

In this chapter, relevant background is provided. Firstly, circular water management is described. Circular water management aims to optimize sustainability by creating a circular water economy. By improving the KAS we can ensure optimal governance around circular and sustainable water innovations. Secondly, since this study is executed within the context of the city of Amsterdam, the situation and important actors of the watergovernance in Amsterdam are described. Thirdly, the program 'Innovation in Watergovernance' is discussed. Not only is this study conducted as a part of the program, it also uses the program to test and evaluate actions (see chapter 5: methodology).

2.1 Circular and sustainable water management

Shortages are rising to provide for needs of the (growing) worldwide population and, paradoxically, there often is a surplus of waste. Therefore, responsible consumption and production is one of the 17 formulated Global Goals for Sustainable Developments (United Nations, 2015). Within this goal, sustainable consumption and production patterns for natural resources (e.g. water, energy, food) are pursued.

Water treatment receives a special focus within the global goal for sustainable consumption and production, since it is one of the biggest issues in the world (together with food and energy). Only less than three percent of the world's water is drinkable, of which two-point five percent is frozen in the Antarctica. Also, still more than one billion people do not have access to drinking water (United Nations, 2015). At the same time humans pollute and use water faster than nature can recycle and purify it (United Nations, 2015).

Frameworks for sustainable resource consumption and production are often aimed on promoting resource and energy efficiency and, creating sustainable infrastructures. By improving resource usage efficiency together with the creation of sustainable infrastructures, a net welfare gains of the supply chain might be achieved. An example of a net welfare supply chain is the idea of circular economy (Preston, 2012; Stahel, 2016). Circular economy is a system designed to maximize reusability of products and raw materials and to minimize value destruction. Goods are no longer used in a linear way but are moving around in a circular loop (see figure 2). The possibilities for reuse, recycle, repair or remanufacturing need to be considered. By closing the loop, dissipation of waste can be reduced (Stahel, 2016) and resources can be used efficiently.

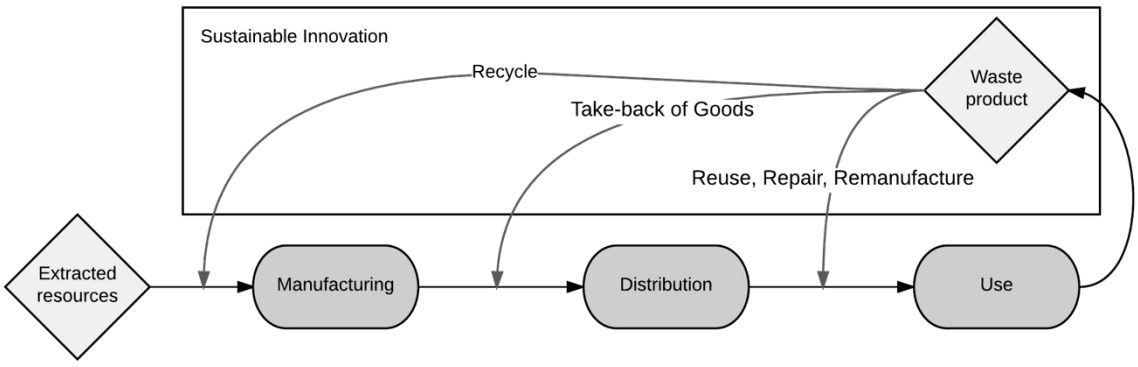

Figure 2. The Circular Economy Loop of resources (Stahel, 2016). Water, energy and natural resources are extracted from nature. During manufacturing, goods are made from scratch. Distribution transfers goods from manufacturer to consumer at point of sale. Consumers use goods, where after, when functionality is lost, the good becomes a waste product. For creating a circular economy, sustainable innovation is needed that allows for reuse, repair, remanufacture and recycle of waste products and hereby transform used goods into 'as-new'. By closing the cycle, less extracted resources are needed for the manufacturing process.

The circular economy can also be applied to sustainable water consumption and production (Kocí, Rocha, & Zakuciová, 2016). A circular water cycle involves a water chain in which water is renewed ad reused more efficiently and in which materials are retaken from waste water. An example of circular economy into water treatment is the reuse of waste water in a decentralized way (waste water gets segregated and energy, or new useful water, gets retaken) (Roest et al., 2016).

This circular water management is a new way of management; therefore, a transition is needed. Transition can be described by the transition management theory (Loorbach, 2010). This theory maps a structured way of change for complex systems. Systems are often complex structures of different actors and technologies, interacting with each other and each fulfilling an own purpose. Actors are built up in this system on different levels. Therefore, multilevel understanding is needed since all levels are involved. There are three levels of interest in a system: the niche, regime and landscape level. The niche, situated on micro-level, is an area in which novelties are created, tested and diffused (Loorbach, 2010). In Amsterdam much research around the possibilities for (decentralized) circular water treatment is done within different niches (van der Hoek, Struker, & De Danschutter, 2017). The regime can be described as the current structure of the system, situated on meso-level (Loorbach, 2010). Right now, the current regime is far from managing water in a circular way (Agudelo-Vera, Leduc, Mels, & Rijnaarts, 2012; van der Hoek et al., 2017). However, the regime needs to investigate into different niches for sustainable water management to be ready when pressure is exerted from landscape level (macro-level). The landscape is the external environment of the regime and can influence the need for this transition (Loorbach, 2010). Climate change and exhaustion of resources are examples for pressures from landscape level (García-Ruiz, López-Moreno, Vicente-Serrano, Lasanta–Martínez, & Beguería, 2011).

2.2 Water management in Amsterdam

Water boards are the ones that take care for a city with regards to water. Examples of tasks are: make sure the city remains dry and safe, make sure the water in the city is clean and make sure all citizens receive drinking water of good quality. These tasks are all performed in an environment which continuously changes and brings new challenges (e.g. rapid urbanization, climate change) (Koop & Leeuwen, 2016). Therefore, innovation is needed to maintain optimal water management and resources at socially acceptable costs. The city of Amsterdam aims to become one of the frontrunner cities with regards to the previous discussed circular water economy (City of Amsterdam, 2012; van der Hoek et al., 2017). The desired state formulated by the municipality of Amsterdam (City of Amsterdam, 2012) and the current state of the water cycle will be described below.

There are several actors involved in water management. The municipality of Amsterdam and the independent water board are the main actors involved in decision making. Amsterdam falls within the area of water board Amstel, Gooi en Vecht (AGV). The water company that executes established policy into practice is called Waternet.

Drinking water in Amsterdam is retrieved from natural sources. This natural water undergoes various purification processes to improve colour and taste and to decalcify it. After this, water is stored in large drinking water reservoirs. From these reservoirs, the water is transported to the consumers by pumps and pipelines. After consumption, waste water is conveyed to a central sewage treatment plant through central sewer conduits. Waste water is yet not segregated; both black (toilet) and grey water (household, minimally dirty) are transported together. Decontaminated water is drained of again, while the remaining sludge and biogas is used by Amsterdam's Energy and Waste Company. It is thought that this system can be organized much more sustainable.

One of the main opportunities for improvement of the water management cycle, seen by the municipality of Amsterdam and water board AGV, is decentralized purification of water. For this, some changes must be made to the current system; waste water needs to be segregated locally at the household. Both grey and black water will be treated within a local purification facility. Grey water is less dirty, and can easily be purified by simple processes to be reused by consumers for, for example, flushing toilets. Black water can function as a source for fertilizers such as phosphate and nitrate. Moreover, the fermented sludge can produce biogas, which can serve as green gas. A total transition of central water management to decentral water management is however, not seen as cost effective yet (City of Amsterdam, 2012).

2.3 'Innovation in Watergovernance' program

As discussed in the introduction, new governance structures are needed to adapt easier to new ways of management. Therefore, the water board AGV initiated the program 'Innovation in Watergovernance' (2017-2019). This program focuses on new forms of water governance that result from circular water innovation. According to earlier discussed transition management principles, this movement can best be performed in co-operation with multiple levels (Loorbach, 2010). Therefore, the program tries to invest in research done in niches at local scale in Amsterdam in co-operation with the water boards and municipalities (regime). The study described in this paper is part of the program and tries to improve the KAS, which will help to improve transition of water management. To put this study in context the bigger program will be described below.

The program focuses on innovation in watergovernance, since administrative renewal is considered crucial to fulfil the ambitions of high quality water management. A key point for innovation is the creation of collaborations (Ghisellini, Cialani, & Ulgiati, 2016), which is also the vision of water board AGV: cooperation between citizens, public and private actors from different technical, physical and institutional domains is required to come to real innovation. Therefore, the main idea behind the program is to bring these different actors together and stimulate cooperation and initiate partnerships. The objective of the 'Innovation in Watergovernance' program is formulated as follows: by taking a KAS building approach where different parties (research, government, practitioners and innovators) exchange knowledge, develop new knowledge and convert it into actual actions, the program contributes to a sustainable and circular water chain. In conclusion, the essence of the innovation that is needed, is creating governance that works together with directors, researchers and practice.

The program contains six design principles: action oriented, inclusive, reflexive, transdisciplinary, responsive and in the field research. The program aims to be action oriented (generated knowledge is tested and performed in practice) by immediately changing the local structures during the program. By having an inclusive design, it strives to include all important actors into the program for generating the most helpful and valuable knowledge. A reflexive design is chosen since the program is an explorative and iterative process. By learning from experiences in a reflexive way, the right steps can be taken forward. Transdisciplinary is needed since different fields come together within the program. The aim to generate knowledge from cooperation between actors from different fields is crucial. Responsiveness was added since the program aims to respond to the different situations the program can face. An in the field design means that the program is placed on the ground. This was included since the program wants to implement action in the practical context of the program.

The program itself is built up from five different themed work packages (WP) that are derived from a first pilot research that was conducted by the Amsterdam Water Science (AWS) institute. The first three WP's each focus on different aspects of research around governance implications from circular water innovation. WP1 studies different governance strategies related to their context. WP2 studies new technical systems and its implications for future governance. WP3 aims to get insights into the legal aspects watergovernance

innovation. The present study is situated in WP4, which studies the KAS of the watergovernance around innovation. WP4 evaluates the other three WPs on the knowledge-action interaction between involved researchers, practitioners and policymakers. Lastly, WP5 is an overarching WP that coordinates the overall program. In figure 3 an overview is provided on the relationship between the different WPs within the program.

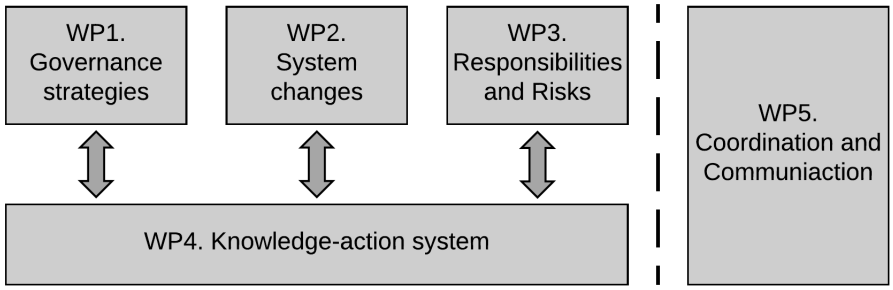

Figure 3. Relationship of WPs in the program 'Innovation in Watergovernance'

3. Theoretical Background

The present study is focused on a KAS; therefore, this concept needs investigation. At the same time, the study aims to find out how improvements can be made to the KAS. The process of system change can be helpful to formulate best ways of improvement. This chapter addresses both topics.

3.1 The knowledge-action system

The KAS is defined as the appearance of the network of production, sharing and use of policy-relevant knowledge by all actors involved (Munoz-Erickson, 2014). Earlier on, the conception about the relationship between research and policy was often seen as a simple linear two-way knowledge-to-action process (figure 4A). Research was developed according to the needs of policy makers, and policy makers used science to formulate policy for practice. This conception, however, has shown to be not realistic. The dynamics of the relationship between research and decision-making is rather complex (figure 4B). To understand the relation between knowledge and action, this complex system between research and decision makers must be investigated and operationalized.

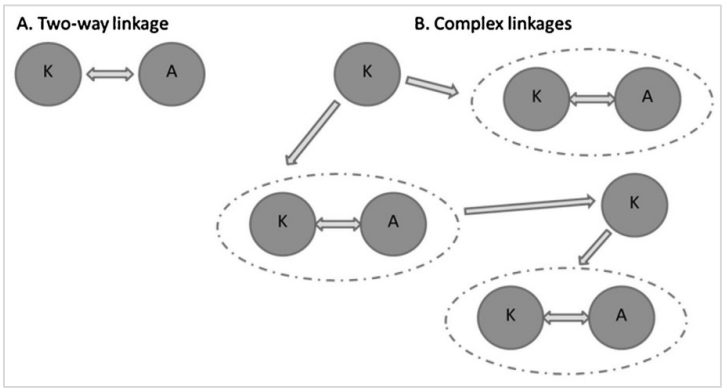

Figure 4. Views on linkages between knowledge and action. (A) illustrates a simple two-way linkage of knowledge and action. (B) shows a complex representation of different knowledge linked to different actions. The linkages are more complex structured. The dashed-lines indicate different cultures in which knowledge and actions can be situated.

To understand this network, Munoz-Erickson (2014) developed the knowledge-action systems analysis (KASA) framework. By using the KASA framework, insights can be generated into how dynamics between knowledge and decision-making look, work, and how these can be improved. The framework is further described below.

The KASA framework, comprises five different steps. These steps are designed based on social science concepts and social network theory concepts (Chan & Liebowitz, 2005; Jasanoff, 2004; Wasserman & Faust, 1994). Social science aspects like culture and power, together with network structures can affect circulation of knowledge involved in governance processes (Munoz-Erickson et al., 2010).

The first two steps of the KASA framework involve the mapping of the knowledge-action network. Munoz-Erickson (2014) did this by using the social network analytical tool developed by Chan & Liebowitz (2005). In the first step, all actors and knowledge involved in the network need to be identified. This step is labelled by the concept *'diversity and inclusion'*. The first indicator for this concept is stakeholder identification. It is tried to identify the relevant actors which are situated in the KAS, regardless whether they are connected to other actors. The second indicator is fragmentation of knowledge (Munoz-Erickson & Cutts, 2016). This indicator aims to identify which knowledge types are included in the network and how these are divided over actors.

The next concept studied in the second step is *'connectivity'* (Munoz-Erickson & Cutts, 2016). The level of connectivity is indicated by the appearance of ties between actors in the network. A tie is defined by the exchange of knowledge between actors. Connectivity gives an indication for the quality of the network. High dense local, issue specific clusters are for example needed when cohesion and trust is necessary for building social capital. Connectivity can also serve as an indicator for barriers in the network. Homophily of connectivity indicates the level of people that are linked to each other with the same perceptions. It is considered that low homophily is often more effective for knowledge-action networks, since this stimulates knowledge flows and initiate management actions (Berardo, 2014; Munoz-Erickson & Cutts, 2016). High homophily on the other hand, can be a challenge for knowledge-action networks to achieve useful outcomes. Another concept for the connectivity is reciprocal type of knowledge sharing. Reciprocal ties are those in which knowledge is shared both ways between two actors. Reciprocal ties are especially crucial when trust is necessary between actors for achieving actions. Reciprocity can allow co-operation and mutual benefit between actors.

The third concept, connected to the second step of the KASA framework, is *'position and power'*. This concept investigates the position and power of different actors identified in the previous step. The centrality of an actor can result in a position of privilege and power over information. There are two types of centrality: degree centrality and betweenness centrality. Degree centrality indicates the number of ties an actor has with other actors. If an actor is popular, many ties will be formed towards the actor (in-degree). When the actor has many outgoing ties, it indicates that the level of knowledge dispersal or advice to other actors (out-degree) is high. Betweenness centrality indicates whether actors are situated between two (or more) other actors, which do not have a connection with each other themselves. This can result in a bridging role for the actor. Actors with a high betweenness centrality are easily able to influence the knowledge flow.

In short, the outcome of the first two steps is an illustration of the whole network with all types of actors involved in the knowledge to action process together with connecting ties. Based on the social network theory, it seems that a more diverse network allows for higher creative and innovative capacities.

The third step in the framework is to analyse '*visions'* for the future. Different dominant visions on what direction development should take for the future influences the effectiveness of the KAS. When central actors (diagnosed in the first two steps) have a dominant vision, knowledge generated by other actors based on different visions are likely to be ignored or lost. On the other hand, a variety in visions allow for a variety of opinions for which more diverse knowledge is generated. Diversity of knowledge results in a higher adaptive capacity of the system; more varied knowledge allows to respond quicker to changing situations.

The fourth step of the framework is to distinguish *'epistemic cultures'*. The visions identified in the previous step are often a result of the epistemic culture the actor is part of. An epistemic culture is a group of people that shares the same norms and values regarding knowledge. Which knowledge is valuable, true or false is defined by the epistemic culture. Due to the alignment principle, people will behave according to the culture of the group they belong to (Guijt, 2010). Therefore, cultures can have a big influence on what knowledge will be used and is chosen to be valuable. Examples of epistemic cultures are the bureaucratic-planning culture and scientific-managerial culture. The epistemic culture can be a barrier when knowledge needs to be transferred from one culture to the other.

The last step is the *'boundary assessment'* step. Not only are there boundaries between different ways of knowing (epistemologies), but also between knowledge and action. Boundary assessment is a term that describes the separation between research and policy and gives appearance to the rigid boundary between knowledge making and decision making as two unconnected activities (Gieryn, 1983). This is

needed for the maintenance of credibility and authority of scientific knowledge in policy-making. However, there are often crossovers between knowledge and action which can steer the knowledge flow and knowledge agenda setting. Because of this, more relevant knowledge may be developed that matches the policy makers practice. The desired shape of the boundary between knowledge and action is discussable per situation. In this step, the border dynamic between knowledge and action is investigated.

Not many other studies have tried to perform or develop similar techniques as the KASA framework before. The KASA framework can be assigned to the Knowledge Management (KM) study domain (Akhavan, Ebrahim, Fetrati, & Pezeshkan, 2016; Becerra-Fernandez & Sabherwal, 2014). Becerra-Fernandez & Sabherwal (2014) defined KM as follows: 'doing what is needed to get the most out of knowledge resources'. The KASA framework is developed based on this similar idea; getting the most out of knowledge resources. The KASA framework however, is special in the way that it tries to embrace a wider network of different actors. KM focuses mainly on individual or organizational level, therefore developed frameworks often lack complexity of a whole work field (e.g. the water sector) that encompasses a network of various actors (Rubenstein-Montano et al., 2001). For this a more systematic approach is needed that does emerge within the KASA framework.

3.2 Organization and System change

The process of system change can be helpful to formulate and apply best ways of improvement. Below, some important models for organizational and system change will be discussed. It is considered that these models of system change can be applied to change of a KAS.

One of the most famous models on change is the unfreeze-change-freeze model by Kurt Lewin (Burnes, 2004). The model was developed in 1947 and has became an accepted model for organizational change. This model assumes a linear process of changes with three stages: *unfreeze, change* and *refreeze.* The three-stage model of Kurt Lewin is, however, a very basic and simple representation of change. Because of this, critics argue that a lot of variables for change are not included (e.g. cultural aspects). Moreover, in contrast to the linear approach of Lewin's model (Burnes, 2004), organizational change is often a continuous and open ended process (Weick & Quinn, 1999).

Another model for change is the OADI-SMM cycle model (Kim, 1998). The model involves a circular shape of four steps. The model relates to the self learning ability of organizations and systems (Kim, 1998). The model stems from an individual learning loop model, applied to the more complex structure of organizations and systems, in which multiple individuals are situated. The OADI-SMM cycle model involves multiple individual learning loop models that influence one main organizational learning loop. For the sake of simplicity, we will only describe a single learning loop.

The OADI learning loop is a circular four-step process (figure 5). In the first step *'observe',* concrete experiences of the current situation are observed. This provides an overview. After this, it is necessary to reflect on the observed situation. This is done in the second step *'assess'*. Based on this evaluation improvements can be designed in the next step *'design'*. In the last step *'implement',* the designed improvements are implemented and experimented with. After this, the first step of observation can take place again. By repeatedly going through this loop, organizations and systems will undergo improvements and adjustments of the present state.

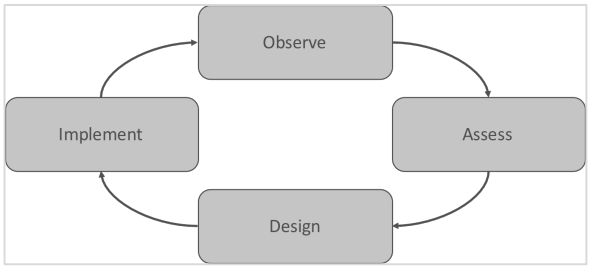

Figure 5. The OADI learning loop model. The four-steps are pictured in a loop, presenting the self-learning process by organizations allowing change to the current state.

Figure 6 shows the action research spiral (Kemmis, McTaggart, & Nixon, 2013). This model describes the process of action research. During action research, the researcher tries to change a setting (which also can be a system) by learning from actions performed. The researcher is often part of the setting, or system, while conducting action research. The action research spiral is therefore very substantially alike the previous discussed single OADI learning loop. Action research can be described as research in which action and learning are intertwined (Brydon-Miller, Greenwood, & Maguire, 2003). Not only the generation of knowledge is important, but at the same time actions can be conducted that can change or improve the practical study field. The action research spiral consists of four main steps: *plan, action, observation* and *reflection*. These four steps are very similar to the steps of the OADI learning loop, since action research is an iterative process in which the researcher learns from experiences and adapts to this in the process further on. The action research spiral starts with a reconnaissance step, in which the current state gets explored. Based on that exploration a guiding study idea can be formed which will be the main goal for the initiation of the research. Towards this goal, the loop repeats itself through one after the other. Actions get planned, performed, observed and reflected accordingly. Ideally, in the end of the process, the desired state is reached in practice, together with the desired generated scientific knowledge. However, the product can sometimes differ from the guiding idea, since strategies or goals can be revised.

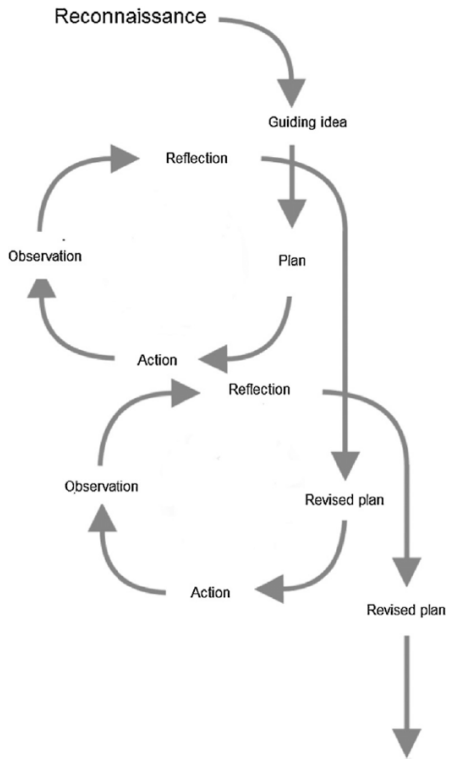

Figure 6. The action research spiral. (Kemmis et al., 2013)

4. Conceptual framework

In this chapter, the conceptual model that is used in this study is discussed. Operationalisations are done to define the main concepts. The conceptual model with operationalization is provided in figure 7.

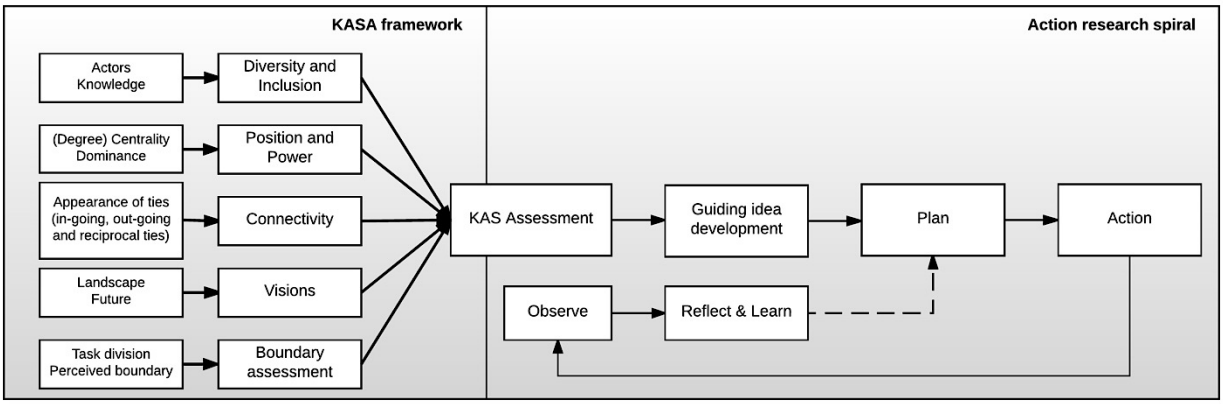

Figure 7. Operationalized conceptual model.

4.1 A model for finding opportunities

For the development of the final conceptual model (figure 7), the KASA framework (Munoz-Erickson, 2014) and the action research spiral (Kemmis et al., 2013) were used. The KASA framework helped to analyse the subject of this study (KAS), whereas the action research spiral was helpful to study how improvements can best be made. Both will be discussed in relation to our study below.

The theoretical background discussed three models for change, respectively the 'unfreeze-change-refreeze' model (Burnes, 2004), the OADI learning loop model (Kim, 1998) and the action research spiral (Kemmis et al., 2013). For this study, the action research spiral was chosen. We as researchers aim to 'change' (read improve) the KAS, while being part of the system. A circular structure for change was preferred, therefore, the 'freeze-change-refreeze' model was not considered useful. The action research spiral was chosen instead of the OADI learning loop model since this model was more in alignment with the process of action research that is performed in this study, however both are substantially the same.

While describing the action research spiral in the conceptual model, the line between theory and methods is narrow. Action research involves action (what you do) and research (how to learn about what you do) (McNiff, 2016). Therefore, the action research spiral implies both method and theory on how to answer the main research question. Discussion in this chapter on this model therefore, indicate methods for the action research (see methodology).

The action research spiral consists of one first step, the reconnaissance and guiding idea development step, and a following circulation of four steps: plan, action, observation and reflection. These steps were used as framework to answer the main research question. First, the reconnaissance and guiding idea development step involved an assessment of the current performance of the system (the KAS around sustainable and circular water management in Amsterdam). Therefore, this KAS must be assessed first.

Assessment of the KAS was done by use of the KASA framework. As described in the previous chapter the KASA framework consists of five steps. These five steps however, needed redesigning for the purpose of this study, since the aim and context differed from the study done by Munoz-Erickson (2014). They applied KASA in the context of land use and green area governance and aimed to provide a comprehensive descriptive overview of the KAS. For describing the KAS around circular and sustainable water

governance in Amsterdam, our priority was to find opportunities for improvement. Therefore, steps were selected that together could provide a representative overview of the KAS and at the same time could provide useful insights into targets for improvement. For these targets of improvement, it is necessary to choose indicators that can be changed. For this reason, the fourth step around epistemic cultures was excluded from the model. This because, epistemic cultures are often fixed and difficult to convert (Knorr-Cetina, 1991). The first two steps, around mapping the network, will be divided into three steps according to the more recent study by Munoz-Erickson & Cutts, (2016) which focused solely on mapping the network. These three steps investigate the following concepts accordingly: *diversity and inclusion*, *connectivity*, and *position and power*.

To measure the *diversity and inclusion* concept, the two indicators mentioned in the KASA framework will be used. All important actors around circular water management in Amsterdam are identified (actor identification), together with an identification of the knowledge present within the network (fragmentation of knowledge). Based on this, the level of inclusion from different actors and the diversity of knowledge are assessed. The concept of *connectivity* is indicated by the appearance of ties that connect different actors. Indicators for the appearance of the ties are in-going ties (knowledge absorption), out-going ties (sharing knowledge) and reciprocal ties (partnerships). Per type was looked at the density and the availability of the ties. If the number of ties between actors is high, it positively influences the knowledge flow and vice versa. The availability of ties is a good indicator to find where barriers are for forming ties. The *position and power* concept was investigated by the concept of (degree) centrality and dominance. While investigating the dominance, it was tried to find out which actors do have authority or a unique characteristic. By investigating the centrality, conclusions about the position of a certain actor were formed as well as the consequential power an actor has over the knowledge flow. Within the circular and sustainable water management sector, investigating the centrality of actors helped to indicate which actors are directing and steering the knowledge flow, and moreover, which stakeholders are potentially blocking the knowledge flow.

The step of exploring *visions* was kept in the analysis, although visions are hard to steer (and therefore to change). However, we chose to keep this step in the analysis. The concept could help indicate why certain knowledge get developed, shared and integrated, and explain directions different actors take. A vision moreover, often determines the goal of and willingness for knowledge interaction (Wehn & Montalvo, 2016). Based on the vision of a certain stakeholder, links of knowledge flows can be formed more suitable. As sub concepts for visions, first was looked at the vision on the current landscape. Within this sub concept, visions on the need for change, visions on the technologies and visions on the public needs were identified. As a second sub concept, visions for the future were investigated. These visions for the future were studied by the desired future state of circular water management of the actor.

Lastly, the boundary between decision making and research was investigated. This *boundary assessment* was done by the indicators of task division and the perceived boundary. The task division described the current distribution of knowledge generation tasks and executive tasks for each actor. By this observation, the current state of the line can be assessed. A strong line between knowledge generation and implementation is mostly not optimal for bridging knowledge to action. However, due to requirements for proper research, it is also important to keep a distance from parties with an interest in the outcome of the research. In the program 'Innovation in Watergovernance', research is done in co-operation with different parties, which often stimulates the knowledge to action. However, this boundary should always be guarded accurately. By knowing the division of tasks, conclusions were formulated about the link between knowledge and action. Moreover, the perceptions on the current boundary were studied. This helped to formulate conclusions about whether a certain state was optimal and desired or not.

According to the action research spiral, the assessment of the KAS should be followed by formulating a guiding idea. In this guiding idea targets get identified, based on bottlenecks that are found from the assessment, on which the actions will be directed. Bottlenecks are characteristics of the KAS that potentially inhibit knowledge flow. By completing the targets, the KAS will be improved.

After this step, the action research spiral follows. In the plan phase, effective actions are designed to improve, or tackle, the targets from the guiding idea. Methods and ideas will be designed on how to improve these and thus, the performance of the KAS. These actions can focus on all concepts of the KASA framework. Helpful literature for developing suitable actions can be derived from knowledge co-production strategies (Edelenbos et al., 2011). Since knowledge co-production is about connecting different actors by working together on generating knowledge, these techniques can especially help improve diversity and inclusion, and connectivity, of the KAS (Hegger, Lamers, Van Zeijl-Rozema, & Dieperink, 2011). Moreover, knowledge co-production helps to mediate between differences in visions from participating actors, to ensure that all actors will benefit from cooperation.

The second step of the action research spiral is about performing the designed actions in practice. This is done within the 'Innovation in Watergovernance' program. Due to the limited study time, only a limited number of actions can be performed.

When the actions are performed, or implemented, observation and reflection must follow. In this study, it is not feasible and not necessary to observe the whole KAS over again. This due to (1) time limits and (2) because actions implemented in the previous step are most likely to be not that influential yet for changing the overall KAS. Therefore, observation and reflection is only done based on the action itself and in small local settings. Based on this, lessons can be learned with regards to the actions. The reflection will be done based on criteria whether the corresponding target is achieved or not. This spiral can occur multiple times in action research, until conclusions can be stated on answering the main research question. In this study however, only one loop will be conducted due to time limitations.

4.2 Sub-research questions

For answering the main research question (how to improve the KAS of circular and sustainable water management in Amsterdam?) sub-research questions are created. These were derived from the final conceptual model (figure 7). The KASA framework in the first step of the action research spiral model answers the first sub-research question:

1. *How does the current KAS (of circular and sustainable water management in Amsterdam) function and what bottlenecks or opportunities can be identified? Based on:*
    a. *How does the 'diversity and inclusion' of the KAS look?*
    b. *What is the 'connectivity' of the KAS?*
    c. *What is the 'position and power' of actors in the KAS?*
    d. *What are the 'visions' in the KAS?*
    e. *How do the current 'boundaries' (between knowledge generation and implementation) in the KAS look?*

The following of the action research spiral answers a second sub-research question:

2. *What are effective actions that could improve and stimulate the KAS (of circular and sustainable water management in Amsterdam)?*

5. Methodology

5.1 Research strategy

In this study, we did a qualitative analysis and applied methods directly in practice. Therefore, the design of our study was action oriented (Brydon-Miller et al., 2003). With action research, researchers can easier understand people and context from practice since they work together, which helps formulating accurate improvements (Kuhne & Quigley, 1997). Since little was known about the topic under study, the study was conducted with an explorative approach and therefore data was inductively generated (D. R. Thomas, 2006). For answering both sub research questions, the study was split up in two phases. Phase 1 answered the first sub-research question and consisted of methods that aimed to assess the KAS while phase 2 answered the second research question by conducting the *'plan', 'action', 'observation'* and *'reflection'* loop.

5.3 Sampling population

In phase 1, the study population consisted of actors that are involved in the KAS around circular and sustainable water management in and around Amsterdam. The recruited actors were subdivided into three subgroups: people from research, practice and government (policy and management). For people from research, respondents were sought that are involved in doing research into the field of circular and sustainable water management. These respondents were part of academic and scientific organizations. Respondents of the policy and management group were people that take part in developing policy and make decisions within this water management field in the city of Amsterdam. This were people from the water board AGV, Waternet and the municipality of Amsterdam. Lastly, practitioners were people that worked in practice. Some worked in local practice initiatives in Amsterdam, as, for example the Buiksloterham and the Ceuvel. These people try out new techniques into practice, organize projects and aim to create circular and sustainable environments (Klaversma, Roest, Smeets, van den Brand, & Cortial, 2016). No specific inclusion criteria were drafted other than that respondents should have been part of the KAS around sustainable and circular water management in Amsterdam.

Since phase 2 aimed to find effective actions that improve and stimulate the KAS, practices were implemented and tested out within the program 'Innovation in Watergovernance'. The program is initiated to carry out research in co-operation with people involved from all fields; researchers, policy makers and practitioners work together to study possibilities for circular and sustainable water management. Inclusion criteria were thus (1) being involved in the program and (2) being part or subject of the actions.

5.4 Sampling strategy and recruitment

Respondents for phase 1 were recruited by a convenience sampling method (Coyne, 1997). Available contact networks known to KWR and the 'Innovation in Watergovernance' program were used. The networks included databases of people that were already contacted for participation for the program 'Innovation in Watergovernance' or that already had shown interest. Respondents were invited to participate in an interview by mail or in person. The mail was supported by information on the goal of the interview and the study. To broaden the network known by KWR and the program, a snowball sampling method was applied (Biernacki & Waldorf, 1981). A small survey (Annex 1) was distributed to all people from the network known by KWR with the question to nominate other actors important for the KAS. These new participants were also recruited by mail, again supported by information. In the end 7 individuals were recruited for phase 1. 23 individuals were already recruited and interviewed by the program, therefore, in total, 30 respondents were included.

For phase 2, the program 'Innovation in Watergovernance' was used. The researcher actively participated in the program, and was therefore, known by most of the members and people involved in the

program. By this, the researcher was easily able to approach the right people for initiation or evaluation of actions. Moreover, the researcher also worked 1 day a week at the headquarter of water board AGV and water company Waternet, which helped to become familiar with policy makers and managers.

5.5 Data collection phase 1

To study sub-research question 1, a small descriptive survey was used to get first impressions on the functioning of the KAS. The survey was distributed among people involved in the KAS around circular and sustainable water management in Amsterdam. The survey contained descriptive questions, based on the conceptual model, on how respondents contribute to and perceive the KAS (Annex 1). Respondents were also asked to name five organizations and people that they used as information source in 2016. Respondents and names that were written down as knowledge source were appointed to its organization. Based on this data, a figure of the KAS was created, using the program Gephi (Cherven, 2013), that indicated the knowledge flow on organization level. By the outcome of these questions a first impression was formed of the KAS, which stood at the basis for the real study method of phase 1: semi-structured interviews (Harrell & Bradley, 2009).

Since this study was rather explorative, semi-structured interviews were conducted. This helped to explore characteristics of the KAS broadly, and at the same time, go deeper into specific characteristics when topics of interest were addressed (Harrell & Bradley, 2009). Clarification of given answers was possible by use of probing questions. However, structure was needed as specific topics on the KAS needed to be addressed throughout the interviews. By use of an interview guide, a structure was created for interviews that ensured discussion of all important concepts for analyses of the KAS. These important concepts followed from the conceptual model. From the 30 interviews included in phase 1, 23 interviews were done with a broad explorative approach towards circular and sustainable water management in Amsterdam and conducted by researchers from the 'Innovation in Watergovernance' program. Within these interviews, the subject of knowledge was included as a subtopic, therefore, only these parts were considered relevant to this study. The 7 remaining interviews were conducted by the researcher of this study, focusing solely on the KAS of circular and sustainable water management in Amsterdam. For this group one overall interview guide was developed (no deviation per subgroup) (see Annex 2).

Depending on personal preferences, a place and time convenient for the participant was pre-arranged. Of the 30 interviews, 28 interviews were conducted face to face and 2, due to practical reasons, by telephone. The 7 interviews on the KAS of circular and sustainable water management in Amsterdam lasted between 19 and 49 minutes with an average of 31 minutes. All interviews were audio recorded and then transcribed for analysis.

5.6 Data collection phase 2

Within phase 2, action research was done to answer sub-research question two. According to the conceptual model, after observation and assessment of the KAS (phase 1), a guiding idea and effective actions that could improve and stimulate the KAS of circular and sustainable water management in Amsterdam were studied.

First, a guiding idea was formed based on the assessment of phase 1 (Kuhne & Quigley, 1997). The guiding idea consisted of targets for improvement. Subsequently, in the 'plan' step (see figure 7), effective actions were devised, based on the outcomes from phase 1 and existing literature (Kuhne & Quigley, 1997). This was done in cooperation with members of the 'Innovation in Watergovernance' program and a knowledge co-production expert.

Subsequently, these practices were actively implemented within the program 'Innovation in Watergovernance'. The program carried out its studies as according to the chosen actions. After

implementation of these actions, reflections were done. This was done by multiple methods to ensure triangulation (Kuhne & Quigley, 1997). During the study time, a log was developed to keep track of simple records (Kuhne & Quigley, 1997). Furthermore, a portfolio was used in which relevant materials during the study time were collected (Kuhne & Quigley, 1997). To generate more profound feedback a questionnaire was used, with both open (useful for exploration and subjective reactions) and closed questions (useful for collecting specific information), together with oral feedback from WP-leaders and other people involved (Kuhne & Quigley, 1997). After evaluation, conclusions were formed for sub-research question 2 on which actions were useful to improve the KAS.

5.6 Data analysis

All recordings from the semi-structured interviews done in phase 1 were transcribed by the researcher. Thereafter, all transcripts were imported into the software NVivo 11 QSR (Bazeley & Jackson, 2013). Within this program a directed content analysis was performed (Hsieh & Shannon, 2005). The coding process was done in three steps: initial coding, axial coding and selective coding. To focus solely on relevant data with regards to the research question (23 interviews were broadly explorative), initial coding was done by using a developed coding sheet based on the conceptual framework (Hsieh & Shannon, 2005). However, room was left open for adjustments to the coding sheet based on new relevant findings from the data (Hsieh & Shannon, 2005). When new concepts were found, which were not possible to subdivide under a concept from the coding sheet, new concepts were added to allow for the most extensive and best descriptive overview of the KAS. Axial coding was performed to these new concepts to organize and categorize all labels into linked groups (Strauss, 1987). This axial coding was performed based on the conceptual model. Lastly, after axial coding, selective coding was done. In this process, the most relevant content was selected to answer the sub-research questions (Strauss, 1987). Additionally, valuable quotations and summaries were selected for each important content category (Strauss, 1987).

Analysis of the data was done in an iterative process. Which means that, when new discovered concepts were added to the coding sheet, previous coded transcripts were analysed again based on this new coding sheet (Holton, 2007). When analysis of transcripts was done, theory to answer the sub-research questions was formed. Together with results from the action research of phase 2, theory to answer the mean research question was developed which resulted in suggestions for improvement of the KAS. At the same time, performed actions during the action research process actively contributed to the improvement of the KAS (McNiff, 2016).

5.7 Validity and Reliability

During the study, attention was paid to ensure the validity of used methods. While conducting study methods in phase 1 (survey, interviews), it was tried to recruit a representative overview of actors for all three subgroups, which improved internal validity (Gray, 2013; Maxwell, 1992). Convenience sampling methods does not guarantee high validity, since sampling is done based on available networks (Coyne, 1997). Therefore, also snow ball sampling was conducted, via the survey, to generate new respondents. By this, the sampling population was made more generalizable towards the real situation and thus, improved validity (Gray, 2013; Maxwell, 1992). Moreover, the aim was to have an equivalent representation for each subgroup so that input would be equal. This ensured that outcomes were not biased by one dominant group. In total, there were 9 respondents from research, 10 respondents from policy and 11 respondents from practice included in the semi structured interviews. The multi-method approach in phase 1 (survey, interviews) ensured triangulation of the assessment, which improved internal validity (Maxwell, 1992; Meijer, Verloop, & Beijaard, 2002).

Data analysis was supported with the use of a scientific conceptual model. Also, the survey and the interview designs were developed based on the scientific conceptual model, which strengthened the internal validity of this study (Maxwell, 1992; Thomas & Magilvy, 2011). The initial coding was done by one researcher and then checked by a second researcher to increase internal validity (Thomas & Magilvy, 2011). The use of the coding sheet and the conceptual model made the process repeatable and transferable for others, which improves the confidence of the study (Maxwell, 1992).

5.8 Ethics

While conducting the study, attention was paid to the traditional ethical considerations (Munn-Giddings & Winter, 2013; Williamson & Prosser, 2002). No harm was done to participants and the study subject (KAS). Confidentiality was always ensured for participants. Sensitive knowledge shared was not used or anonymised. The researchers of the study did not distort data at any time. While translating the quotes from Dutch the English, it was always guaranteed to keep the same content. Participation in the study was voluntary, and respondents could withdraw at any times. Moreover, informed consent was sought from each interviewee prior to the interview (Chuang & Man, 1983). This informed consent included: information about the study, assurance of confidentiality of information shared and maintenance of anonymity for any quotations used in academic presentations or publications. Since action research does not only study and observe a subject, but also tries to influence practice and the way people think, additional ethical considerations must be made (McNiff, 2016; Williamson & Prosser, 2002). While doing the study, permission for access to different areas was always negotiated with members of the program. Information was continuously shared and outcomes were aligned with respondents. Since the study was not perceived controversial (all respondents agreed with the purpose of it) no further ethical considerations were made around further potential (political) consequences for respondents.

6. Results

In this section, the results for both phases are shown each answering a sub research question. First phase 1, about the assessment of the current KAS of circular and sustainable water management in Amsterdam, is discussed. Bottlenecks and opportunities are identified. Secondly, the action research of phase 2 is described.

6.1 Assessment of the KAS (phase 1)

In this chapter, the results of the KAS assessment are provided. This is done based on a survey and semi structured interviews with relevant stakeholders. Each concept of the conceptual model (Diversity and Inclusion, Connectivity, Position and Power, Boundary Assessment and Visions) is discussed.

The survey was completed by 33 respondents. The work sites of respondents were mainly located in Amsterdam (14 people), with others from Nieuwegein (4), Rotterdam (3) and Utrecht (2). The remaining 9 respondents had a different work site spread over the Netherlands. The respondents were however, all involved in the KAS of Amsterdam. 12 Respondents worked in the Policy and Management domain, with functions as policy advisor (5), policy officer (1), legal advisor (2), strategic advisors (3) and process manager (1). 10 Respondents worked in the research domain, all working as researcher from different organizations and some additionally as lecturer. 10 Respondents worked in the practice and technology domain, with people who were: (co)owner of a practice or technology related company (5), consultancy advisors (2), quarter maker (1), architect (1) and sales manager of a technology related company (1). One respondent worked as program maker, addressing topics around circular and sustainable water management with meetings and thus, was an intermediary between the three domains. It is concluded that the sample population of the survey was a highly varied but balanced group, and can therefore, be considered representative for the KAS.

An overview of the 30 respondents of the semi structured interviews is displayed in table 1. As described in the methodology, 23 interviews were done by researchers from the 'Innovation in Watergovernance' program with a broader approach towards circular and sustainable water management (R8-R30) and 7 interviews were done specific on the KAS (R1-R7). For each respondent, the actor domain and the organization type is shown. In total, there were 9 respondents from research, 10 respondents from policy and 11 respondents from practice included.

Respondent	Interview perspective	Actor domain	Organization
R1	KAS	Policy and management	Water company Waternet
R2	KAS	Policy and management	Municipality of Amsterdam
R3	KAS	Policy and management	Water company Waternet
R4	KAS	Practice and technology	SME
R5	KAS	Practice and technology	SME
R6	KAS	Practice and technology	SME
R7	KAS	Research	University
R8	Broad explorative	Policy and management	Municipality of Amsterdam
R9	Broad explorative	Policy and management	Water board AGV
R10	Broad explorative	Policy and management	Water company Waternet
R11	Broad explorative	Policy and management	Water company Waternet
R12	Broad explorative	Policy and management	Water company Waternet
R13	Broad explorative	Policy and management	Water board AGV
R14	Broad explorative	Policy and management	Water board AGV

R15	Broad explorative	Practice and technology	Consultancy
R16	Broad explorative	Practice and technology	Housing corporation
R17	Broad explorative	Practice and technology	Architectural office
R18	Broad explorative	Practice and technology	Energy utility
R19	Broad explorative	Practice and technology	Living lab
R20	Broad explorative	Practice and technology	Freelance innovator
R21	Broad explorative	Practice and technology	Living lab
R22	Broad explorative	Practice and technology	Housing corporation
R23	Broad explorative	Research	Water Research Institute
R24	Broad explorative	Research	University
R25	Broad explorative	Research	Water Research Institute
R26	Broad explorative	Research	University
R27	Broad explorative	Research	University
R28	Broad explorative	Research	Consultancy & Research Institute
R29	Broad explorative	Research	University
R30	Broad explorative	Research	University

Table 1. Overview of respondents.

6.1.1 Diversity and inclusion

The first concept to be discussed is the diversity and inclusion concept. This concept was operationalized in the conceptual model by two indicators: fragmentation of knowledge and stakeholder identification. Together these results provide an indication for the diversity and inclusion concept.

Knowledge diversity and inclusion

Within the KAS of circular and sustainable water management in Amsterdam there was found to be much knowledge available. With regards to different kinds of knowledge, technical knowledge was dominantly present. This logically follows from the fact that it is a technological oriented work field. Respondents stated that all technological knowledge can be found and, if not yet, will easily be developed and become available in the future.

Another kind of knowledge well present within the KAS is social science knowledge. Respondents stated that this kind of knowledge is emerging right now, especially within the research domain, but also within the policy and management domain, as one social researcher explains:

> *"I think it grows, (...) such an organization as Waternet, with all those local initiatives and small-scale innovations they are a bit worried now. Because they have a governance model that fits a large-scale system that is from the last century. And so, they acknowledge that something must happen in the field of governance. But how to handle all those little initiatives? You must deal with it differently than if you have a large-scale system. And that requires social science research. And not just technical as it used to be." R7*

Furthermore, one respondent indicated that Amsterdam encounters social issues earlier than other cities, since it is a leading city in the Netherlands. Within the actors from practice, social science is limited.

Even though there is much knowledge present within the KAS, respondents stated that there are still underrepresented areas of knowledge. Mentioned areas were: economic knowledge, legal knowledge and knowledge about scaling up. One respondent from the water board AGV indicated:

> *"I think research is very technical and social science dominated and it has little economic and financial input. And that is in the end, whether you like it or not, which will make it work or not." R9*

A need for more economic knowledge was mainly stressed by actors from policy. They believed that researchers should incorporate the economical side of their findings more within their outcome. The lack of legal knowledge was mentioned mainly by respondents from practice. For them, legal aspects of their work are often unclear and complicated. This, mainly because they are the ones that work on the legal borders of the system. Moreover, since there are many extremely novel technologies there often is no corresponding legal environment yet, or an old fashioned one. Altogether, it is stated that legal information is hard to find. Actors from policy and management stated that actors from practice lack knowledge on scaling up. This implies knowledge on the functionality and applicability of technologies in a broader context. The practical knowledge on technologies that is produced by practitioners, such as innovators and pioneers, is often hard to translate to the broader context.

It was stated by many actors from practice that the integration of different kinds of knowledge is needed. Some practical actors develop knowledge focused only on one topic. However, an integral approach is rising in Amsterdam. The water company Waternet is unique in the Netherlands for including the water chain within one company. Additionally, in practice local initiatives with a more integral approach towards innovation are emerging too.

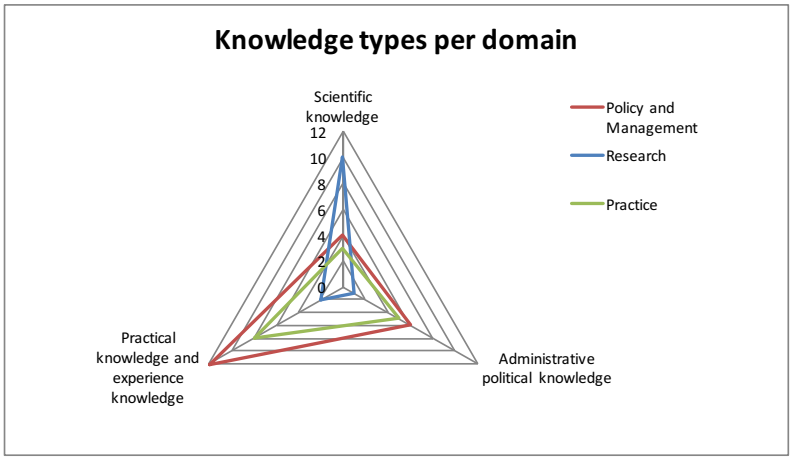

Figure 8. Knowledge types per domain. For each domain three different knowledge types are divided over three axes. The axis indicates how many times a certain knowledge type is indicated by respondents as a type he or she deals with in his or her work.

According to the results mentioned above, it seems that knowledge is differently divided over researchers, practitioners and policy decision makers. This was also indicated by the survey in which the fragmentation of knowledge types and knowledge areas were studied per domain. Figure 8 and 9 show that each domain differs with regards to knowledge content. The policy and management domain seems the most diverse with a high diversity of knowledge types, scoring high on all three axes (figure 8). Looking at the knowledge areas of this domain (figure 9), natural science and technical knowledge is highly prevalent, with less social science. The practice domain deals with less knowledge than the other two domains, however, the domain consists of diverse types of knowledge (figure 8). In this domain, natural science and technical knowledge is most prevalent (figure 9). For fragmentation of knowledge per domain, we can conclude that each domain is different with regards to types and areas. It seems that the policy and management domain is most divers, whereas the research domain is the least.

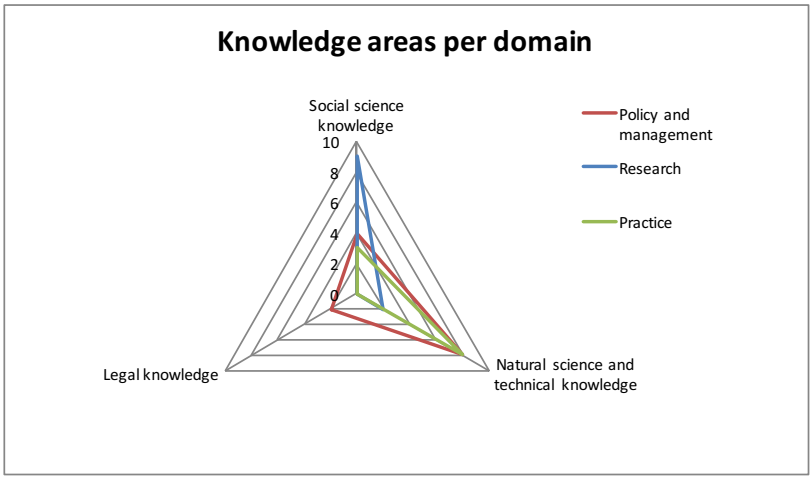

Figure 9. Knowledge areas per domain. For each domain three different knowledge areas are divided over three axes. The axis indicates how many times a certain knowledge area is indicated by respondents as an area he or she deals with in his or her work.

As already discussed, many knowledge is available within the KAS, however much of this knowledge is lost. Within many local initiatives lots of practical knowledge is generated, however, not always properly captured and secured. Moreover, within the policy domain many actors work on their own subjects and generated knowledge during their work is often not captured. One respondent from the water company in Amsterdam stated:

> *"Well, what I think we really do not well is to systematically gather knowledge and make it available. There is no system behind it. We do not have a decent library function or something." R1*

In conclusion, it seems that there is a lot of knowledge available within the KAS which is differently divided over the three domains. Especially technical and social knowledge is present. Moreover, a good feature is the availability of integral knowledge within the KAS. However, a bottleneck is the underrepresentation of certain types of knowledge, as economic knowledge, legal knowledge and upscale knowledge. Additionally, another bottleneck is the poor retention of knowledge within the domain of practice and, policy and management domain.

Opportunities	Bottlenecks
• A lot of knowledge available (especially technical and social knowledge) • Availability of integral knowledge	• Underrepresentation of certain types of knowledge (economic knowledge, legal knowledge and upscale knowledge) • Poor capturing of knowledge (practice and, policy and management)

Table 2. Overview of opportunities and bottlenecks Knowledge diversity and inclusion.

Actor diversity and inclusion

To assess stakeholder diversity and inclusion, a network analysis was done based on the survey (see chapter 5.5). Based on this data, a figure of the KAS was created that indicates the knowledge flow on organization level (see figure 10).

Organizations from all three domains were present in the knowledge flow map. From the policy and management domain actors as the water company Waternet, water board AGV and the municipality of Amsterdam were included. From the research domain, independent research institutes as KWR and AMS (Amsterdam institute for Metropolitan Solutions), and many universities, as Wageningen university, University

of Amsterdam and TU Delft, were included. Actors from the practice domain included local citizen initiatives (Citylab Buiksloterham, GrownDownTown, Ecodorp Boekel, Schoonschip), consultancy organizations (Metabolic, Tauw, Water Innovation Consulting), technology organizations (Desah BV, Landustrie, MijnWaterfabriek), architects' desks (One Architecture) and an independent discussion platform organization (Pakhuis de Zwijger).

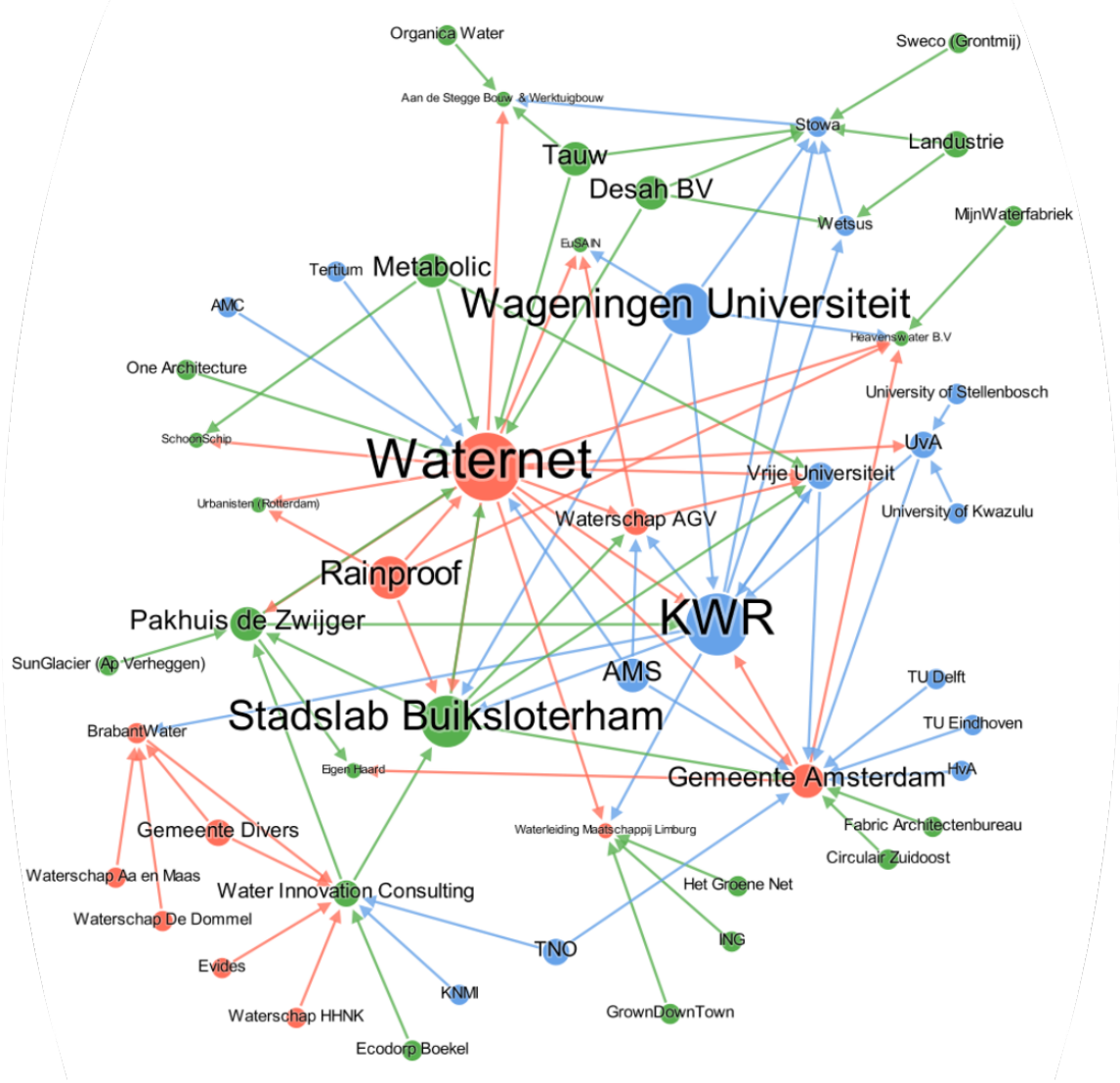

Figure 10. Knowledge flow map of the KAS. The network map shows the knowledge flow with regards to circular and sustainable water management for each actor. The arrows indicate the direction of the knowledge flow. The colours indicate to which domain the actor belongs (policy and management is red, research is blue and practice is green). The weight (or size) of an actor indicates whether the actor has many outgoing ties (big is more outgoing ties).

In addition, respondents themselves also stated that the KAS of Amsterdam included many experts and professional actors. A positive feature was the high number of local innovative initiatives in practice that explore possibilities and contribute valuable new practical knowledge. Furthermore, it was generally accepted by respondents that most actors from the research domain were renowned and recognized organizations. Also, one respondent stated that within Amsterdam there are many progressive actors involved.

Nonetheless, also some negative features for actor diversity and inclusion were stated by respondents. Respondents provided several examples of actors that are not included in the KAS, but believed to be needed. Moreover, the water sector is seen by some respondents as a small world, in which actors

know each other well, which leads to a lack of new perspectives. Therefore, people from outside the water sector were needed. One respondent indicated:

> *"We keep celebrating the party with ourselves, but I think it's going to be the challenge to engage people other than people from the water sector, within this theme. There is a need for more diversity than just the water sector." R9*

Required actors from outside the water sector that were stated are: users of the water system (citizens), people from other sectors (especially the energy sector), and housing corporations. Actors from the policy and management domain mentioned that more inclusion of citizens could be helpful to focus knowledge generation more on what society demands. Actors from the energy sector could be helpful since this sector has undergone a similar process as the water sector is facing right now. Moreover, with the construction of buildings, there are often interfaces where the two sectors can be connected and where cooperation can be beneficial for both. Some respondents from policy mentioned the lack of inclusion of housing corporation actors, since they are the ones to build houses and implement new technologies. However, due to the lack of inclusion their knowledge and perspectives remains hidden for certain actors.

Another negative feature, which was mentioned by actors from practice, was that inclusion often depends on coincidence. Since there is no system available that visualizes and indicates the different players in the field it is unclear and sometimes confusing to find the person one is looking for. As a result, actors can be missed or ignored and the ones that get included are often the ones that are already known. One respondent indicated therefore, the need for a more open competition structure for actors from practice to participate in different projects, instead by choice from above for one partner (excluding others).

In conclusion, there are many valuable actors from different domains involved in the KAS. These are often renown and recognized players, with high quality of contribution. The KAS also consists of progressive players. However, there is a lack of inclusion of actors from outside of the water sector, as user and citizens, actors from other sectors (as the energy sector) and housing corporations. The lack of a clear overview of the actors results in inclusion by coincidence and exclusion of lesser known actors from practice.

Opportunities	Bottlenecks
• Many valuable actors involved (within all three domains)	• Inclusion from outside of the water sector (user and citizens, energy sector and housing corporations) • Inclusion based on coincidence (no clear overview of actors available)

Table 3. Overview of opportunities and bottlenecks Actor diversity and inclusion

6.1.2 Connectivity

As previously concluded, there is a large amount of knowledge present in the KAS. However, the KAS can not fully benefit from this when no optimal connections between actors exist, as one respondent explained:

> *"Well, I think everyone has a lot of knowledge in his own field. But, of course, connecting the right people at the right time is the real deal. So, the technique is not the problem, but the process is the problem." R22*

Unfortunately, right now, some respondents stated that there is no clear knowledge network observable. One responded described his perspective on this knowledge network:

> *"Oh, well, for me, there's no such thing as a knowledge network. I see that there are all sorts of different parties active. But I do not see that as a cohesive whole yet, there are many loose initiatives going on. That is how I see it. And of course, Amsterdam is at least a very progressive city, which is developing a lot. (…) But it is very fragmented. So, there is no, I still experience it as loose sand." R6*

This suggests that the KAS is lacking ties. However, figure 10 shows many different knowledge flows between organizations. We will further investigate three different appearances of ties below, respectively in-going ties (knowledge absorption), out-going ties (sharing of knowledge) and reciprocal ties (partnerships).

In-going ties (knowledge absorption)

In-going ties exist when actors use other actors as knowledge source. Within this KAS, the in-going ties depended on the knowledge the actor needs. Therefore, in-going ties were mostly need-driven.

An indicator for in-going ties is the availability of knowledge. Based on the survey it can be concluded that the availability of knowledge still can be improved, since 53% of the respondents indicated that they sometimes would want to have more knowledge but they do not know where to find this knowledge, and 10% more stated that they would want to have more knowledge but they can't get access to it. Reasons for this can be the poor recording and capturing of knowledge (as discussed in the previous paragraph) and a lack of a clear indication of where specific knowledge can be found. The remaining respondents (37%) stated that it could be that they miss out on important knowledge, however, they are not aware of this. No respondent stated that it can always find the relevant knowledge it needs. These outcomes indicate that, despite the high number of ties, not all knowledge need is saturated and people still feel a need for more knowledge exchange.

Respondents from practice stated that they mainly retrieved knowledge from big organizations, such as Waternet and municipalities, and consultancy organizations, such as Metabolic. The connection between practice and scientific knowledge institutes can sometimes be poor. One respondent indicated:

> *"Well, there is always a tension field between practice and research, especially if you work with knowledge institutions, between knowledge and applicability. Our intent is that we want to market and a knowledge institute wants to gain knowledge, and that does not always match." R5*

Nevertheless, respondents from practice all agreed that it is not too hard for them to find the knowledge they need.

An important connection that should be improved, according to many of the respondents, is the in-going connection from society to research. Respondents stated that there sometimes is a mismatch between the focus of research and the answers society demands. A respondent from the policy and management domain explained this importance based on her own organization:

> *"If the aim is just the creative knowledge-enhancement, then it's going to diverge. I see that within my organization. If the strategic center diverges from the organization simply because they are doing fun investigations, it does not match any longer with what is needed by the organization, it does not match. Then it's just a nice research institute, but it is useless for the organization." R1*

The insufficient in-going knowledge flow from society to research is supported by figure 10. Not many ties can be seen from actors from practice towards actors from research (considering actors from practice as actors that are derived from society).

Out-going ties (sharing of knowledge)

Respondents from research concluded sharing knowledge was hardly a problem. Knowledge is easily exchanged within this domain. However, respondents from practice and, policy and management, did state bottlenecks for the out-going ties.

Many respondents from practice indicated that they love to share knowledge with other actors and where rather benevolent towards sharing knowledge. Some organizations however, are depending on the value of their knowledge, and therefore often work with discretion. As one respondent stated: knowledge is power. Especially for small local initiatives, it is not easy to share knowledge they possess. Competition is thus a limiting factor for out-going ties within this field. Although knowledge was not easily shared between practitioners, it was mentioned that sharing knowledge with water boards and municipalities was easier, due to the absence of competition.

Respondents from the policy and management domain also indicated some bottlenecks with regards to out-going ties. First, water boards do not openly share their data, which could be a missed opportunity since it possesses large data sets. One respondent questions herself:

> *"Why don't we just make it available for people who can profit from it? So, we have that discussion about the data, and then we will have a whole discussion about the intellectual property of the data and what you can do with it." R1*

Another respondent stated that, due to the poor sharing of knowledge within a policy and management organization, employees often work past each other, not being aware of what its colleagues know. Moreover, knowledge sharing between policy and management organizations is poor too. As with actors from practice, competition is a limiting factor between water boards and municipalities. One respondent described the relationships between water boards as follows:

> *"The water boards also compete with each other. They do not work together. They all want to be more important than the other, and everyone wants their head in the newspaper and in the news. So yes, if one water board does something with one organization, the other water board does something different. These are not conscious choices. They just compete." R15*

Reciprocal ties (partnerships)

To achieve change, many respondents agreed that collaborations between actors are most valuable. Furthermore, it seems that partnerships are rising within the KAS. However, according to one respondent, the most valuable collaboration form still happens too little: collaboration by really doing, working together, in practice. Partnerships are now often only limited to the exchange of knowledge.

Water company Waternet is collaborating a lot with many actors. Actors from practice get embraced, such as city lab Buiksloterham, and research institutes, as KWR, UvA, TU Delft, Wetsus, AMS and Stowa, get involved within different projects. Furthermore, it also collaborates a lot with the municipality.

It seems that municipalities do have good ties with practice, research and fellow policy actors. The connection that could be improved is the one between the water board AGV and the municipality. AGV itself often acts on the background, behind Waternet, but is not well connected.

Respondents from practice state to have great collaborations with policy and management actors, however, ties between practice and research could be improved. As the earlier stated poor knowledge flow from practice to research, partnerships between these two domains are also lacking. One actor from practice stated about this relationship:

> *"Well, at a distance. We are, of course, very active in practice, from practice. So, I'm there, and I follow from a distance what is being developed of scientific knowledge, but we are standing far away from it."* "Should this be improved?" *"Well that would be good. That would be valuable. Especially when you talk about product innovation or system innovation, there must be an interplay between practice and general knowledge development." R6*

On top of that, some respondents indicated the value of more partnerships in projects with citizens, but this can be stated for all three domains.

It can be concluded that there is a high density of ties within the KAS. Many respondents were positive about the ability to share knowledge and create partnerships. Furthermore, the connection between policy actors and actors from practice is improving. However, some bottlenecks for the connectivity of the KAS were observable. Respondents stated that they sometimes miss out on knowledge by different reasons. This, mainly because it can be unclear where the right knowledge can be found. Moreover, competition within actors from practice as well as within certain actors from policy and management also contributes to this bottleneck. Another bottleneck is the connection between research and, society and practice. Connecting these could be helpful for generating more valuable knowledge.

Opportunities	Bottlenecks

• High density of ties
• Ability to share knowledge and creating partnerships
• Connection between policy and practice is improving
	• Missing out on knowledge:
	  ○ Unclear where to find knowledge
	  ○ Competition (within both practice and policy domain)
	• Connection between research and practice

Table 4. Overview of opportunities and bottlenecks Connectivity.

6.1.3 Position and Power

Based on figure 10, which shows outgoing knowledge degree (weight of the circle), it seems that there are certain actors who are more dominant than others with regards to outgoing knowledge flow. Especially the water company Waternet is a major player with regards to knowledge. Many actors indicated to use this organization to find and retrieve knowledge. Other main organizations according to this figure were Wageningen University, KWR water cycle research institute and city lab Buiksloterham. Based on this figure, it cannot be concluded if these organizations do have more power. However, due to their high outgoing degree centrality it is likely that they possess more influence over the knowledge flow.

In addition, during the interviews, many respondents indicated Waternet as a dominant player as well. This is mainly due to the reason that many actors stated to be dependent on Waternet when carrying out their tasks. Waternet itself, however, seems quite autonomous in setting out its directions. One researcher stated:

> *"Waternet is quite autonomous. Of course, they must deal with the water board AGV, it is still organized by government. So that's very political. But Waternet an sich, yes, they are quite autonomous to determine directions." R28*

Besides the water company Waternet and water board AGV, another powerful actor is the municipality of Amsterdam. As one respondent stated:

> *"It is not up to the water boards only to make decisions, in fact they are even following. If a municipality builds a district and decides that they do not drain it, we will just get no waste water. And we can not force municipalities to sew a district." R14*

The dependent actors were often the ones from practice. According to them, local innovation initiatives depend on the established order, which can limit innovation processes. For them, it is hard to develop if they do not work in partnerships with the establishment. These partnerships though, are often chosen by the powerful actors based on coincidence or even nepotism. On the contrary, respondents from policy and management often believed to be an important incubator for change, by stimulating partnerships and budgeting the initiatives. Furthermore, one respondent from the policy and management domain stated:

> *"We sometimes stifle innovation, because the general interest is not as progressive as innovation can be. I do not think everything should be an innovation. People also have to live, and life is a fairly conservative thing." R1*

Nevertheless, there are actors in the practice domain with a special status given by actors from policy, such as city lab Buiksloterham. This helped creating more powerful actors within the practice domain and strengthened their position.

In short, there are some dominant actors within the KAS. These are actors that have a dominant outgoing degree centrality (and hereby influence knowledge flow), and actors which have power over other actors (and hereby influence the directions of innovation directly). Creating more powerful actors within all domains was perceived useful.

Opportunities	Bottlenecks
• Stimulation of more powerful actors in practice by policy	• Dominant actors influence the directions of innovation

Table 5. Overview of opportunities and bottlenecks Position and Power

6.1.4 Boundary assessment

Based on the survey, a strong division between knowledge generation and application was not desired by most respondents. Respondents agreed it is the duty of all actors to generate knowledge and that this knowledge may be used by everyone, over the believe that knowledge should only be generated by knowledge institutes. Moreover, when asked whether respondents saw themselves as knowledge producer or knowledge user, most saw themselves as a bit of both (see figure 11). Below, a further investigation of the division of tasks per actor is described.

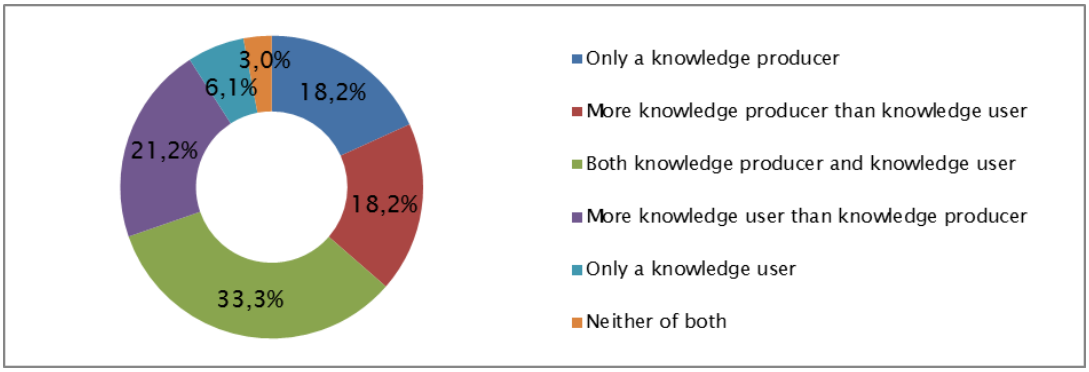

Figure 11. Knowledge producer vs. knowledge user. Respondents answered one of the options that applied the most.

Respondents from policy stated executive tasks as the primary ones of the organization. However, knowledge management is getting more important, because executive tasks are shifting; creating awareness in the public domain, evaluation of outcomes of performed tasks and assisting citizens is getting more important. Therefore, more knowledge is needed on the performance and efficiency of the organization and its actions. Moreover, it was stated that, since these actors want to evolve together with innovation in society, they also should cooperate in knowledge processes with society. One respondent indicated that Waternet is already starting to do more research themselves.

The main task for actors in the research domain is knowledge generation. Moreover, some researchers saw providing knowledge as their only responsibility:

> *"No, it is not our cup of tea. We do technology and technological issues. We use a lot of data from regulations and we try to use reasonable assumption of what the impacts are of the technologies we develop. And we write it nicely down so that other people can use this information to make regulations." R25*

However, some respondents from other domains stated that it is also the responsibility of researchers that their knowledge is seen by the right people. Thus, suggested they should focus more on what happens next with the generated knowledge.

Respondents from practice often believed that their tasks were both aimed on generating knowledge and, implementation and innovation. One respondent from practice saw this intertwining of research and application as a future trend:

> *"I think that, more and more, it intertwines. You can not have separate units of research and application anymore. (...) I think that it will flow more into each other and that you will get much faster spirals of research and application." R20*

Local initiatives generate knowledge by trying things out, and at the same time implement new techniques and change the environment. Housing corporations and some technology corporations saw their primary tasks as only implementation.

In conclusion, it seems that the boundary between knowledge generation and implementation is decreasing. Policy actors, such as Waternet, start to do research themselves; local practitioners start to intertwine knowledge generation and implementation. This decreasing boundary is perceived useful for the KAS since generated knowledge will be more relevant and will result easier in application. Researchers however, keep having a clear focus on knowledge generation, but could focus more on what happens next with the generated knowledge according to actors from other domains.

Opportunities	Bottlenecks
• Decreasing boundary between knowledge generation and implementation (within both policy and practice)	• Researchers can improve focus on what happens next with generated knowledge

Table 6. Overview of opportunities and bottlenecks Boundary assessment.

6.1.5 Visions

Despite that some respondents believed the circular thought to be rising, the urgency for change of the current water management system was still perceived low by respondents from research, housing corporations and, policy and management. Often a decisive factor was lacking. Moreover, they mentioned that business cases are no match to current structures as one respondent explained:

> *"Yes, water is still cheap. We have the best water in the world, and the cleanest too. So, the urge is not so big." R3*

Respondents from practice, however, believed in the urgency for change, which is not surprising since they started initiatives. They often felt a need to have more self-determination over their wastewater and a need for change towards more climate-proof cities. Nevertheless, they acknowledged that most people do not like change, and that there are disagreements in vision surrounding this topic of urgency.

By respondents from all three domains it was often believed that the public opinion has no interest in the technologies and innovation. One respondent from practice had the feeling that everybody is always against everything. Moreover, citizens were portrayed as passive followers, not interested in self regulation of their water system. One respondent from policy described a study done by Waternet among its customers:

> *"Look, the within the city labs there is much idealism, there are many people with idealism over there. We, Waternet, have recently investigated, how many of our customers are interested in sustainability. Well that's about 20%. That is still relatively high. In socially critical Amsterdam, it may be even somewhat higher. But there is also 80% who says, oh, that does not matter to me. I want to be taken care of, I do not want to be bothered, I want to flush the toilet and that is it." R12*

The believe of low public interest lead to a lower perceived urgency for change by policy and management actors, since they act in the public interest.

Visions on the impact of the technologies that are currently developed differed between domains. Respondents from practice were relatively more positive towards the feasibility of the technologies than respondents from policy and management. Subsequently to this, the impact was also perceived different. There were respondents within all three domains that believed new circular technologies to be the future. However, within the policy and management domain, there were also respondents that did not fully believe in the impact of the technologies. Below, the contradiction between a practitioner and a manager is displayed:

> *"In the long run, I think it's efficient for society, that social costs will be better, if you are going to do it decentralized." R15 (practitioner)*

> *"Because our water treatments are now extremely efficient and cost effective. It is therefore very questionable whether all these decentralized forms of treatment are really more effective." R14 (manager)*

Nevertheless, in the end, all respondent shared the vision of circular and sustainable cities. A circular approach was a desired state for the future, shared by all participants. The interpretation of this desired state however, differed. Some practitioners believed in a fully decentral circular future of water management, whereas policy makers and managers insisted on more hybrid systems of water management. Within these hybrid systems, the decentral approach consists next to the central system. One respondent stated:

> *"Decentralization is not an end goal. We are looking for the scale level at which something is feasible. Everything we do must have a business case that comes to zero, because everything we spend is translated directly to what the citizen must pay annually." R13*

In conclusion, most respondents were positive for moving towards circular and sustainable cities. However, the perceptions on the urgency for change and, the feasibility and impact of the technologies could differ per respondent. These differences in vision could harm the knowledge flow about this topic of decentral technologies within the KAS. Nonetheless, this relation did not become clear from the available data.

Opportunities	Bottlenecks
• All actors are pro circular and sustainable cities	• Differences in vision on urgency for change • Differences in vision on the feasibility and impact of the technologies

Table 7. Overview of opportunities and bottlenecks Visions.

6.2 Improving the KAS (phase 2)

In this chapter, the results from phase 2 are described. First the identified targets, the designed methods and actions performed are described. Subsequently evaluation of performed actions is discussed.

6.2.1 Identified targets and performed actions

For each concept, different opportunities and bottlenecks were found. Table 8 shows a complete overview of the important opportunities and bottlenecks that were identified in the assessment of phase 1 per concept.

Concept	Opportunities	Bottlenecks
Diversity and inclusion	• A lot of knowledge available (especially technical and social knowledge) • Availability of integral knowledge • Many valuable actors involved (within all three domains)	• Underrepresentation of certain types of knowledge (economic knowledge, legal knowledge and upscale knowledge) • Poor capturing of knowledge (practice and, policy and management) • Inclusion from outside of the water sector (user and citizens, energy sector and housing corporations) • Inclusion based on coincidence (no clear overview of actors available)

Connectivity	• High density of ties
	• Ability to share knowledge and creating partnerships
	• Connection between policy and practice is improving
		• Missing out on knowledge:
		  ○ Unclear where to find knowledge
		  ○ Competition (within both practice and policy domain)
		• Connection between research and practice

Position and Power	• Stimulation of more powerful actors in practice by policy	• Dominant actors influence the directions of innovation
Boundary assessment	• Decreasing boundary between knowledge generation and implementation (within both policy and practice)	• Researchers can improve focus on what happens next with generated knowledge
Visions	• All actors are pro circular and sustainable cities	• Differences in vision on urgency for change • Differences in vision on the feasibility and impact of the technologies

Table 8. Overview of opportunities and bottlenecks per concept.

Based on the results of phase 1 (table 8) three main targets were selected (see table 9). Firstly, it was chosen to improve the diversity of the network, since one bottleneck of the KAS was the lack of diverse knowledge and actor inclusion (table 8 'diversity and inclusion'). It was concluded that the KAS of the water management sector consisted mostly of known circles of similar people. Secondly, it was chosen to aim on strengthening network relations of the KAS, since it was often not clear for participants where to find the right actors and knowledge (table 8 'connectivity), and inclusion was often based on coincidence (table 8 'diversity and inclusion'). Additionally, the poor relation between research and practice could be improved (table 8 'connectivity'). The third target was strengthening knowledge exchange. Bottlenecks identified that could harm this knowledge exchange process were: competition within actors from practice and within some actors from policy and management (table 8 'connectivity'), the dominant players that influence knowledge flow and directions of innovation (table 8 'position and power') and the discussed differences in visions in the urgency for change and impact of the technologies (table 8 'visions').

Identified targets	Main Actions	Evaluation methods
Improve diversity network	• Knowledge Workshop Water • LinkedIn group	• Questionnaire • Composition workshop & LinkedIn
Strengthen network relations	• Knowledge Workshop Water • LinkedIn group • Website	• Questionnaire • Oral feedback
Strengthen knowledge exchange	• Knowledge Workshop Water • LinkedIn group • Website	• Questionnaire • Oral feedback

Table 9. Identified targets with corresponding actions and evaluation methods.

To improve the identified targets, three main actions were formulated (table 9). Within the 'Innovation in Watergovernance' program three methods were already in preparation phase: starting up knowledge workshops, a website and a LinkedIn group. Therefore, in cooperation between the researcher of this study and researchers from the 'Innovation in Watergovernance' program these methods were linked to the three identified targets. The researcher of this study actively contributed to the execution of the actions, however, the final actions were a product of teamwork.

The Knowledge Workshops focused on all three identified targets. Knowledge Workshops meant: bringing together different people in a series of meetings to discuss related topics concerning circular water innovation. The meetings were held in a 'world café' setting (Fouché & Light, 2011). The 'world café' method is a conversational process that let actors engage in constructive dialogues around complex topics, while building relationships and foster collaborative learning (Fouché & Light, 2011). By bringing together different people, it was aimed to improve diversity of the network. The organizers could influence the composition of attendees by targeted invitation. Invitees were gathered from all three domains (research, practice and, policy and management) and were considered important for (or part of) the KAS. At the same time, it was also free to sign up. Additionally, it was tried to have an equal representation per domain for each meeting to prevent for one dominant group that steers discussion. Since the 'world café' setting allowed for building relations, discussions with new, unknown actors could result in new made connections and thus, subsequently, could improve the diversity of the network. The Knowledge Workshop moreover focused on strengthening the network relations between actors. In line with the 'world café' method it was made evident for attendees that the intention of the meetings was to organize innovation together. Hereby, it was intended that discussions were carried out without a hostile approach, but rather done from a partnership perspective. The underlying thought was that a sense of togetherness helped strengthening relations. Relations were moreover strengthened by improving understanding between actors (from within and between domains), since they learn new perspectives. Sustainable relations could be triggered by repeating these meetings and thus, keep bringing together the same people over periods of time. The third target of the Knowledge Workshops was strengthening the knowledge exchange between actors. The 'world café' setting, in which discussions take place around a complex topic, enables collaborative learning and collective discoveries and thus, implies that actors share knowledge between each other (Fouché & Light, 2011). Topics for discussion were derived from the 'Innovation in Watergovernance' program. The chosen topics for discussion needed exploration by participants. By this, each participant could contribute their own knowledge and expertise in the discussion and thus, stimulate knowledge exchange.

In the end, two Knowledge Workshops were organized within the time of this study. The first meeting consisted of 42 attendees (20 research, 12 practice and technology, and 10 policy) and the second meeting consisted of 53 attendees (18 research, 11 practice and technology, and, 18 policy and 6 board management). Before each meeting, a participant information sheet was sent to all attendees with information about the program and an overview of other participants. The first Workshop was held on a

morning from 9am to 12pm and the second Workshop was held two months later, on an afternoon from 5pm to 8pm. The focus and structure of both Workshops differed and can be found in Annex 3.

To further strengthen knowledge exchange, a website was developed around the program 'Innovation in Watergovernance'. Besides serving as an information website of the program, it included additional tools to exchange knowledge. A platform was developed that allowed people to share messages. Messages could be about meetings, related projects, related news, reports or updates on the program itself. This was done in blog style with links to further information. The feature did not work optimally during the time of this study, since only the website administrator was able to post messages. Messages needed therefore to go via the administrator. In the end, 10 individual messages were posted on the website during the study period: 5 blogs about experiences or acquired knowledge from one of the Knowledge Workshops, 2 announcements with invitation for a new Knowledge Workshop, 2 individual blogs about the program and 1 blog presenting the results of a finished study done within the program (WP2). All messages were written and posted by actors from the research domain.

To contribute to the target of strengthening network relations, another additional feature of the website was a page with an overview of the participants of the knowledge action network. The people involved in the program and other relevant actors were visually displayed with a profile picture, contact information and information about their profession. This was done to create more clarity around actors within the KAS about who are involved and doing what, and to increase accessibility to encounter different actors.

Additionally, to the Knowledge Workshop and the website, a LinkedIn group was initiated. This LinkedIn group aimed to improve the diversity of the network and strengthen network relations. LinkedIn functioned as an extension of the website, where further discussion could take place around related topics. Within the group, updates on the program and the website were posted, and in addition, members of the group could also post messages themselves to start discussion.

The LinkedIn platform provides insights into other members of the group, which could improve the visibility of the actors in the KAS. Together with this, it was possible for the researcher to study the composition of the group and possibly steer this composition by targeted invitation. The LinkedIn group was initiated after the first Knowledge Workshop; all attendees were invited for the LinkedIn group. Two weeks after, the group consisted of 47 members (19 research, 12 practice and, 16 policy and management). Subsequently, targeted invitation was applied with the aim to improve diversity. At the end of the study period the group consisted of 109 members (26 research, 39 practice and, 44 policy and management).

6.2.2 Evaluation of performed actions

Evaluation was done to find out whether the performed actions helped to reach the identified targets, and thus helped to improve the KAS. The Knowledge Workshops were evaluated by: a questionnaire conducted after the second meeting (Annex 4), the composition of the attendees and by oral feedback from participants. The website was evaluated by oral feedback from members of the 'Innovation in Watergovernance' program. The LinkedIn group was evaluated by the composition of the members and by oral feedback. The evaluation for each action is shown below.

It seemed that the Knowledge Workshops were very helpful for improving network diversity. Based on the questionnaire, it was found that most participants saw the improving of the network as the best feature of the meetings. Most people agreed that they had come to meet new people (see figure 12). Moreover, to a lesser extent, these were people with different visions. Attendees liked that they had discussions with people from all layers of the field of work. The diverse composition of attendees was

enforced by targeted invitation. The 'Innovation in Watergovernance' program possessed of a known community of actors that are part of the KAS. To reach out to new, unknown actors a snowball method was applied. Via the survey of this study, respondents were asked to name at least five persons from whom they gained knowledge (or shared knowledge with) over the last year. Subsequently, besides the already known community of the program, all the named people from the survey were invited as well. This resulted in an additional number of 15 attendees (of the 42 total attendees). For the second Workshop, the focus was on inviting policy and management actors, since these were the least represented group in the first Workshop. Eventually, this group became the best represented group in the second Knowledge Workshop (from 10 policymakers to 18 policymakers and 6 board managers AGV). It is concluded that, by targeted invitation the composition of attendees can be steered and, along with the highly positive networking feature of the Knowledge Workshop, the diversity of the network can be improved.

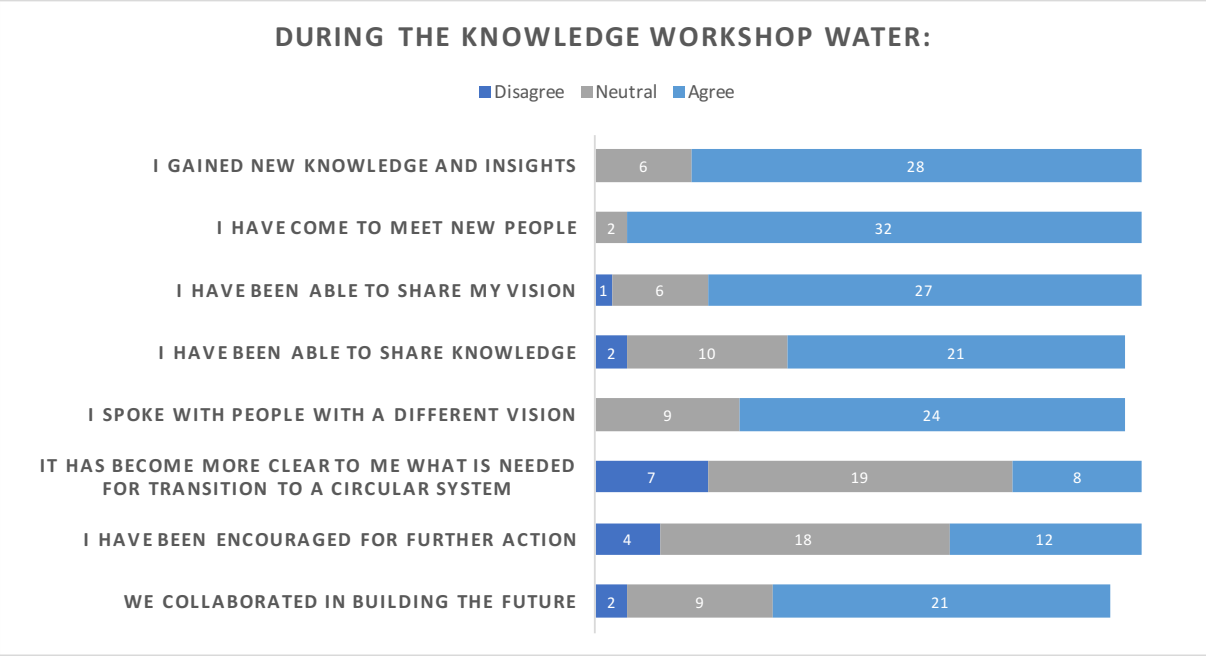

Figure 12. Multiple choice evaluation after the second Knowledge Workshop Water. The form was completed by 34 attendees. The score is displayed by means of number of times an answer is given (4 missing).

The composition of the LinkedIn group was highly influential by targeted invitation. After the first member check (two weeks after the initiation), researchers were dominantly present in the group. To reach out for more new people from practice and, policy and management, one key actor from the water company Waternet, who was thought to have many connections with people from both practice and policy, was asked to invite all relevant actors out of his LinkedIn connections. In the end 190 people were invited to join the LinkedIn group. This resulted in a sharp increase of members from practice and policy (12 practice and, 16 policy and management to 39 practice and, 44 policy and management). By inviting relevant people from outside the water sector it should be possible to broaden the network. However, it is unclear if the LinkedIn group really helped initiating new connections between actors, other than just providing a helpful oversight and visualization of all members in the group. It cannot be concluded therefore whether it really improved diversity of the network.

The Knowledge Workshops were useful for strengthening network relations. It was believed by most participants that attendees collaborated in building the future during the meetings (figure 12). Having this sense of togetherness helped to connect. Respondents were positive about the fact that during the meetings

one shared vision was created and interconnections were reinforced. The ability to share visions and perspectives also helped to improve understanding between participants (figure 12).

The LinkedIn group and the website did not contribute much to strengthening relations in the network, other than making actors more visible. The researcher of this study considered the effect of the website low, since it was not optimal performed during the time of the study. On the website, many actors were missing or attached with incomplete descriptions. This was mainly due to technical complexities. The LinkedIn group may be a more direct platform for creating connections, however, most users were rather passive users of the platform. Since the platform is a solid designed platform it is not easy to present members in a clearer way than currently provided by LinkedIn. A benefit of LinkedIn was that most actors were already familiar with the platform, whereas the website had to be newly introduced. It was concluded that both platforms were not that useful for strengthening network relations. The website does have potential for providing helpful clear visualizations and overviews of the network, since this platform can be improved at own discretion. The LinkedIn group may be used as an address book by members.

To strengthen knowledge exchange, the LinkedIn group seemed not useful. As already stated, members were rather passive users of the platform and therefore passive users of the LinkedIn group. All messages, except one, were posted by researchers of this study. The messages were mostly on the new blogs available on the website. Messages resulted in zero discussion. The one message coming from a member of the group did neither led to discussion. The website did help to share knowledge, but the site was not optimal yet. Posts needed to go via the administrator for placement and therefore messages were only posted by members of the 'Innovation in Watergovernance' program. It is concluded that the website does have a potential for improving knowledge sharing, but features of the site should be improved.

The Knowledge Workshops were useful for stimulating knowledge exchange. Most respondents stated they had been able to share knowledge (figure 12). Also, they mentioned they did gain new knowledge and insights during the meetings (figure 12). Exchange of knowledge was mentioned as the second-best feature of the Workshops (after diversity of the network). This indicates that during discussions knowledge is well shared between participants. Gaining knowledge was the main reason for coming to the meeting which indicate the need for sharing and gaining more knowledge in the KAS.

Besides the positive indications, knowledge exchange within the Knowledge Workshops can be further improved. Respondents did not often state they gained more substantive knowledge on what is needed for transition (figure 12). Respondents mentioned that topic of discussions could be more focused or specified, which was now perceived too broad. According to respondents, this lack of concrete focus could lead to repetition of discussions, without taking it a step further. Participants stated a need for a longer discussion times, since rushed discussions hindered in-depth discussions. Another negative feature was the lack of concrete outcomes. Respondents did not perceive the outcomes of the Knowledge Workshops as concrete enough for further targeted actions. This is in line with figure 12; respondents did not all agree that they were encouraged for further actions. Members of the 'Innovation in Watergovernance' program agreed that the Knowledge Workshop should lead to more concrete actions. According to them, it should be clearer for them what the outcome of a meeting will be, or can be, so that topics of the meetings will more actively flow from the work packages (WP1, 2 & 3) of the program. It was now perceived that a topic was sought just for the sake of organizing a meeting. The goal of the Knowledge Workshops must be the outcome of the discussion, rather than just bringing actors together. This may help exchanging more valuable knowledge. In conclusion, as points of improvement respondents suggested to make discussions more focused on concrete actions as outcome, allow for more in-depth discussion and choose clear and tangible topics for discussion (preferably following from the need of research in the program).

7. Discussion

The study was conducted with the aim to investigate how the KAS of circular and sustainable water management in Amsterdam could be improved. This was done by first answering two sub research questions:

1. *How does the current KAS (of circular and sustainable water management in Amsterdam) function and what bottlenecks or opportunities can be identified?*
2. *What are effective actions that could improve and stimulate the KAS (of circular and sustainable water management in Amsterdam)?*

7.1 Opportunities and bottlenecks of the KAS

From this study, there is reason to assume that the current KAS of circular and sustainable water management in Amsterdam may function properly. Based on the different sub concepts many positive features were found. These positive features are at the same time opportunities. A complete overview of the opportunities can be found in table 8. By making better use of these opportunities the KAS can be used optimally.

The opportunities (table 8) were specific for the circular and sustainable water management context of Amsterdam. A study done by Van Leeuwen & Sjerps (2015) studied the sustainability of integrated water resource management in this same context. They compared and listed cities (worldwide) based on their blue city index (BCI). The BCI is an index based on 8 categories that indicate the sustainability of the integrated water resource management. It was concluded that Amsterdam was among the top countries compared to others. The city scored high on all categories of the BCI index. This is mostly thanks to the multi-level watergovernance approach that exists in the city. Water company Waternet is a unique water company since it integrates the whole water chain within one company (drinking water and waste water). This helped initiate innovation, as for example recovering phosphate from waste water. The findings by Van Leeuwen & Sjerps (2015) confirmed the conclusions in the present study with regards to the opportunities Amsterdam offers for the KAS. It was found that the KAS consists of lots of available expertise and knowledge (especially technical and social knowledge) and the unique integral knowledge approach was considered valuable. Moreover, the large number of valuable actors present in the KAS is underlined by the high BCI score. The conclusion in the present study, that connection between policy and practice is improving right now was underlined by Van Leeuwen & Sjerps (2015), who concluded that water management actors (especially Waternet) were involved in many external collaboration with all types of organizations (research institutes, NGOs, industry and private companies). Furthermore, they concluded that Waternet clearly communicates with their customers.

Nevertheless, besides the positive conclusions for the Amsterdam water management, in the present study also bottlenecks based on negative features of the KAS were identified. Table 8 shows a complete overview of the identified bottlenecks. The main bottlenecks of the KAS are discussed below.

It is found that the KAS underrepresents three types of knowledge (economic, legal and upscale knowledge). In literature it was found that lack of economic knowledge highly inhibits the transfer of knowledge to action (Ghisellini et al., 2016; Kiker, Bridges, Varghese, Seager, & Linkov, 2005). It is indicated that different knowledge types are needed for decision making by policy and management actors; it consists of trade-offs between socio-political, environmental, ecological, and economic factors (Kiker et al., 2005). Moreover, the economic return on investment is stated to be one of the main reason for success stories of circular economy innovation implementation to work (Ghisellini et al., 2016). This explains why, in the

present study, especially respondents from policy and management stated the lack for more economic knowledge.

The KAS also lacks inclusion from actors outside the water sector. It was especially proposed that, by including actors from the energy sector (which has already undergone a similar transition) valuable lessons can be learned. As well as the water sector right now, the energy sector needed policy and system restructuring for making the transition (Kern & Smith, 2008). This transition of sustainable energy systems in the Netherlands required a lot of research in niches and cooperation from regime actors. It was concluded that during the energy transition, the dominance of regime actors highly influenced the direction of niche innovation, which was the main barrier for radical innovation (Kern & Smith, 2008). Furthermore, since there are tradeoffs between water resources and power generation, it is stated in literature that an integrated water and energy management structure yield interesting implications for better outcomes (Chen & Chen, 2016; DeNooyer, Peschel, Zhang, & Stillwell, 2016).

Another actor group that should be more included in the KAS were the citizens (users of the water system). A study done by de Graaf & van der Brugge (2010) indicated that the role of citizens is changing during water management transformations. They investigated a new water management strategy in Rotterdam, combining the renewal of water infrastructure with neighborhood revitalization projects. During the transformation, citizens were no longer seen as client, but became a source of context specific knowledge and co-producers (de Graaf & van der Brugge, 2010). This new role for citizens during water management transformations needs to be considered while transforming current circular and sustainable water management in Amsterdam. Therefore, it underlines the importance for inclusion in the KAS.

De Graaf & van der Brugge (2010) furthermore indicated the changing role of housing corporations during water management transformation. Housing corporations changed from partners for creating high quality urban environment to external stakeholders that presents the context in which water retention is realized (de Graaf & van der Brugge, 2010). This actor group should therefore, also in line with the present study, be more included in the KAS.

It was also found that knowledge is not always captured well in the KAS. Mainly within practice and, policy and management organizations generated knowledge can be lost. Proper knowledge management however, is crucial for organizations to grow and to make transitions work (Bogner & Bansal, 2007). For this, knowledge needs to be captured optimally and it is needed to ensure no knowledge will be lost. In literature it is found that new technologies can help improve storage of both internal and external knowledge management (Santoro, Vrontis, Thrassou, & Dezi, 2017; Soto-Acosta & Cegarra-Navarro, 2016).

Another bottleneck of the KAS is the missing out on knowledge by different actors included in the KAS. Van Leeuwen & Sjerps (2015) also stated in their BCI analyses information sharing as a lesser point for the sustainable water management of Amsterdam. According to them, data and information can be shared more transparent with other actors. It is, nonetheless, currently on the water management actor's agenda to explore ways of data transparency improvement. Proper knowledge exchange is crucial for innovative systems (Wehn & Montalvo, 2016). According to the dynamic Knowledge Transfer (KT) model by Wehn & Montalvo (2016), which describes the dynamics of knowledge exchange, knowledge exchange is achieved when both provider and recipient are willing to transfer knowledge. This willingness is derived from the attitude, external pressure and the control over knowledge transfer. In the present competition was one of the reasons for poor knowledge exchange. In line with the KT model, competitive factors influence the attitude towards knowledge transfer, and thus, the willingness to transfer knowledge by knowledge providers. Moreover, it was found it was often unclear for actors where they could find relevant knowledge. In

the KT model this is the factor defined under the control over knowledge transfer (technical, organizational and institutional capabilities) by the recipient. This directly influences both the willingness to access knowledge transfer of the recipient as well as the knowledge transfer itself.

The connection between research and practice of the current KAS is poor and could be improved. This is supported by Benard & de Cock-Buning (2014) who indicated that practical implications remain largely unreported in scientific literature. Mutual learning helps to solve this problem, but both groups face various barriers during these processes. In literature, the troublesome connection between researchers and decision makers is also often described (which was not identified in the present study). Barriers presented for this troublesome connection in literature apply to the connection between researchers and practitioners. Crow-Miller et al. (2016) stated three barriers. A first barrier was the lack of transparent communication and trust between potential collaborators. This suggests that steps must be taken to develop regular communication for strong, trusted working relationships. Second, there is often a mismatch between the goals of researchers and water utilities for generating knowledge. Utilities seek to serve the immediate needs of their customers and researchers seek publication and funding opportunities in a slow-moving reward structure. This also applies to practitioners, who are often searching for quick practical solutions which can be implemented immediately. Thirdly there is the issue of misaligned expectation and rewarding systems. What is ultimately rewarded for utility personnel differs from those operating in academe. In addition, Cvitanovic et al. (2015) stated a fourth barrier: the lack of applicability. That policy decision makers state a lack of applicability can be, according to this literature review, because of the conventional approach to knowledge exchange. In this conventional approach scientists make knowledge available to the wide world, and therefore try to make knowledge as general as possible so this could be used by a wide range of people. However, to make knowledge applicable to the specific context in which it is carried out is of high importance for success. Since scientific knowledge often provides general conclusions it can lack to acknowledge the specific context as social context and the multiplicity of actors involved for one specific situation (Cvitanovic et al., 2015; Gilbert, Stocklmayer, & Stocklmayer, 2013). A way in which this knowledge exchange process may be improved according to the review, is by embedding scientists in the decision-making process.

7.2 Effective actions for improving the KAS

Effective actions to improve the KAS were: Knowledge Workshops and digital platforms (website and LinkedIn group). However, effectivity differed per action. The actions were developed to serve three identified targets: improving the diversity of the network, strengthening network relations and strengthening knowledge exchange. These targets were chosen because it was found in literature that knowledge exchange and collaborations of all actors involved are essential for the transition towards a circular economy (Ghisellini et al., 2016).

Knowledge Workshops were very helpful for improving all three targets. Network diversity was improved by creating new relations between participants. Targeted invitation moreover, helped to steer composition of attendees. The sense of togetherness and the ability to share visions and perspectives helped to connect and strengthen network relations. This finding confirms the results of a study in Denmark, where a Knowledge Workshop on sustainable urban water management also led to increased understanding between different participants (Nielsen & Jensen, 2016). They observed that participants did not know each other when they arrived on the first day of the course, but over three sessions they developed a shared language and a way of cooperating with one another that demonstrated mutual understanding of each other's interests and skills. Another study, which applied 'World Café' workshops with local experts and practitioners around urban green building transitions, concluded that it increased mutual understanding as well and moreover, improved knowledge exchange between all participants involved (Preller, Affolderbach,

Schulz, Fastenrath, & Braun, 2017). In the present study, it was also concluded that the Knowledge Workshops were useful for stimulating knowledge exchange. Besides the positive indications, there is also reason to believe that knowledge exchange within the Knowledge Workshops can still be improved. Points of improvement suggested by respondents were: make discussions more focused on concrete actions as outcome, allow for more in-depth discussion and choose clear and tangible topics for discussion (preferably following from the need of research in the program). In future Knowledge Workshops these recommendations should be considered to ensure optimal knowledge exchange.

Literature suggests that digital platforms are helpful to improve knowledge management (Santoro et al., 2017; Soto-Acosta & Cegarra-Navarro, 2016). By use of social network sites, wikis, blogging etc. knowledge exchange can be improved (Soto-Acosta & Cegarra-Navarro, 2016). In the present study however, the LinkedIn group was not useful for strengthening knowledge exchange within the time frame of the study. This indicates that methods were perhaps not optimally performed. In literature was found that competition can be a reason for low knowledge exchange since it negatively influence web-based knowledge exchange (Popa & Soto-Acosta, 2016), however due to the insensitive topics it is questionable if this was the main reason in the present study. To improve member participation it is suggested in literature that it is important to improve trust within the platform community (Yang, Li, & Huang, 2017). Also familiarity with the platform and commitment-based human resource practices can positively affect web knowledge exchange (Popa & Soto-Acosta, 2016). It was concluded that the website and the blog feature did have a potential for strengthening knowledge exchange, however, the technical components of the site should be improved by, for example, making it more accessible to post a blog for all actors. The LinkedIn group may be useful for improving network diversity. By inviting relevant people from outside the water sector it should be possible to broaden the network, since targeted invitation strongly influences the composition of the group. However, it cannot be concluded if it really led to new connections between actors. In addition to that, in literature was found that social network platforms are mainly used for networking with the already known (Coyle & Vaughn, 2008). The LinkedIn group and the website did not contribute much to the strengthening of relations in the network. The LinkedIn group may be a more direct platform for creating connections, however, as already stated most users were rather passive users of the platform. It was concluded that both platforms were not optimal for strengthening the network relations, however, the website does have potential for providing helpful clear visualizations and overviews of the network, since this platform can be improved at own discretion.

7.3 Strengths and limitations

While conducting the study it was tried to perform optimal methods. However, unintended limitations did occur. Both strengths and limitations are discussed below to evaluate the study.

For assessing the KAS in phase 1, the KASA framework was used. This helped to define key points that describe the appearance of a KAS. The five sub concepts studied in this research were studied according to the performance of an earlier assessment done by Munoz-Erickson (2014). In the study of Munoz-Erickson (2014), however, no comprehensive operationalisations of the concepts were provided. Therefore, operationalisation of the concepts in this study was based on the described results and findings in the study by Munoz-Erickson (2014). This could have caused certain aspects of concepts to be underexposed. To compensate for this, concepts were compared with descriptions from other studies to maximize the completeness of the analysis.

To achieve a representative overview of the current KAS different actors were identified. This was not only done by convenience sampling (available contact list within the 'Innovation in Watergovernance' program), but also by snowball sampling method (survey). This resulted in the fact that participants in this

first phase of the study were all from different fields and together represented a complete KAS. However, due to this same method one limitation may be that only connected actors of the KAS were included in this study. Unconnected actors of the KAS could have been missed, which may have led to biased findings. A strength of this study was the equal division of respondents per domain. Moreover, the organization types of the respondents were quite divers.

By choosing two methods (survey and interviews) for studying the first sub research question, triangulation was ensured. The survey helped to explore and get first impressions on the features of the KAS, whereas the interviews helped to deepen the impressions and substantiate them by finding out the underlying thoughts and perspectives. This led to a more complete analysis. In the end, it was concluded that findings from both methods were mostly in agreement with each other (which suggests proper internal validity). Furthermore, to answer the overall main research question, also a combination of methods was used. Qualitative analytical methods were performed as well as actions research methods in practice. The value of learning from mistakes while performing actions in practice on a scientific grounded basis cannot be underestimated. It resulted in a strong theoretical, as well as empirical basis for answering the main research question.

The main limitation of the study with regards to the action research conducted within phase 2, was the time restraint. In the end, actions were performed and studied over a period of 3 months (April to June). Within this period all three actions were performed (in cooperation with researchers from the 'Innovation in Watergovernance' program) simultaneously. The focus of the researcher within this study therefore, had to switch between three actions. This resulted in limited attention for some actions over certain time periods. If more time was available, actions may have been conducted better with more commitment. Actions like chasing discussion within the LinkedIn group and optimizing the technical features of the website could have contributed to better outcomes of the actions. Due to the time limit, the study was furthermore restricted to the choice of three actions and the performance of only one full loop of the action research spiral. Other potential actions, with regards to knowledge co-production and strengthening the KAS are most likely to be missed. The answer provided to sub research question 2 was thus, not comprehensive. Since only one loop was performed, optimization of action did not take place (apart from integration of feedback from the first Knowledge Workshop into the second). Another major limitation due to the time restriction was the difficult assessment of effect. The impact of actions was not measurable yet, since it is assumed that this need more time. Most respondents and participants moreover, were not yet aware or familiar with the actions taken. Habituation of actions may positively influence outcomes.

Despite these limitations, the action research in phase 2 did include both digital and physical actions. This widened the scope of the actions. Furthermore, since actions were applied in practice, the study directly contributed to improving the KAS. Also, the set-up actions will continue to exist within the 'Innovation in Watergovernance' program.

7.4 Implications of the study

The present study did build further on the concept of KAS, developed by Munoz-Erickson (2014). It did apply the KASA framework in the context of circular and sustainable water governance in Amsterdam. It provided insights into how the concept can be applied to a sector with multiple actor domains involved and one which is working towards a transition. The KASA in this study was used to find opportunities and bottlenecks of the KAS. Furthermore, the present study went beyond the idea of single assessment, but also applied practices to improve the KAS, what is not yet done before. Improving a KAS can promote a governance system by making it more flexible and resilient for future trends. The study showed how actions can be developed around specific targets derived from the KAS assessment and how these can best be performed. The study showed

that by first analysing the KAS of a sector or system, more targeted and useful actions can be developed and formulated for improvement.

For each different sector and governance field a different KAS will be in place, therefore, actions described in this study will not be directly generalizable towards other sectors and systems. However, when after assessment of a KAS similar bottlenecks are found, the findings in present study can be used to develop and perform actions for improvement of the KAS.

The study furthermore contributed to a better understanding of the current circular and sustainable watergovernance in Amsterdam and therefore functioned as an important building block for WP4 of the 'Innovation in Watergovernance' program. It provided insights into the relations within this sector between different actors from all fields and the corresponding features with regards to knowledge (generation, exchange and implementation). Insights into how actions can be performed and how these can best be taken forward are valuable for further development of the digital strategy and future Knowledge Workshops. All WPs of the program can profit.

For making the proper transition towards circular and sustainable water management, this study directly helped by reaching out to all actors involved and highlighted the importance to them of collaboration while managing the transition. The study included actors from all fields and functioned as mediator between researchers, practitioners, policy makers and public managers and brought them closer to each other improving the knowledge action network.

8. Conclusion

The main research question of the study was:

How to improve the KAS of circular and sustainable water governance in Amsterdam?

Crucial for improving a KAS was to firstly find out the positive and negative features of the KAS. These features were considered opportunities and bottlenecks of the KAS. By making use of the opportunities and by reducing the bottlenecks, this study contributed to the improvement of the KAS of circular and sustainable water governance in Amsterdam. Opportunities for the water governance were the high level of knowledge and actors currently present in the KAS, the decreasing boundary between research and implementation, which helps to develop valuable and applicable knowledge, and the generally accepted vision of circular and sustainable cities among all actors in the KAS. Bottlenecks that limited the KAS were the lack of diverse actors and knowledge types inclusion, loss of valuable generated knowledge (in practice and, policy and management) and the missing out on relevant knowledge by different actors in the KAS.

Based on this study, we concluded that three types of actions can be used for improving the KAS. Knowledge Workshops with discussions in 'world café' setting turned out highly valuable for improving all three identified targets in this study. It should be tried to generate the most divers attendance with actors from all fields, domains and layers. Furthermore, digital platforms were useful as support for the KAS, since they help to make the network more visible and transparent. Knowledge exchange on the website in blog style should be further developed and stimulated, because it has potential to improve web-based knowledge exchange.

8.1 Recommendations for practice

The study provided insights into the current KAS and tried to actively improve it. However, the study was restricted by time. Some recommendations are therefore formulated to take improvement of the KAS of circular and sustainable water governance in Amsterdam forward.

To ensure optimal water governance while facing transition towards circular water management, it is recommended that actors from all fields collaborate. We especially recommend reaching out for actors from the energy sector, users (citizens) of the water system in Amsterdam and housing corporations, and let these actors participate in knowledge co-production projects. More specific knowledge with regards to economic and legal aspects of circular and sustainable water management should be included and shared among actors. Policy actors should enhance their legal knowledge with regards to innovative techniques and share this with actors from practice. More economic knowledge can be developed by actors from all domains, but is especially needed from practice actors to make their innovations applicable for real implementation.

The developed website during the study time was promising with regards to strengthening knowledge exchange. Features of the site should be further developed. It must be made possible for all actors to post messages and share knowledge on the platform. Moreover, the knowledge shared, should be displayed and ordered more clearly. The overview page of actors within the knowledge action network should be expanded and displayed more clearly. Research going on within the program should be made more visible on the site. For example, an overview can be provided on what research is going on right now within the different WPs together with an overview of all interviewed respondents.

Due to the passive behavior of members, zero discussion took place on the digital platforms. Both digital platforms, website and LinkedIn, should be more stimulated to reach optimal knowledge exchange. This can be achieved by asking specific members from different domains to react on posts or by posting

more discussion provoking messages. Also, when members from the practice and, policy and management domains are more included, it can provoke more discussions, since now only the research domain was represented on the digital platforms.

The Knowledge Workshops were found particularly useful for strengthening the KAS of circular and sustainable water governance. Therefore, we recommend to further develop and apply this kind of meetings. Based on recommendations for improvement by respondents, we recommend organizing meetings every 2 months, with a more specific topic following from research of the program that desires concrete outcomes. Discussion time during the meetings should be enlarged.

We further recommend researchers from WP1, 2 & 3 to improve the focus on what happens next with their generated knowledge. This can be done by participation in research in cooperation with practitioners (instead of just observing practice). Also, by providing products that are written down specific for each target group, knowledge may be better translated from research to other actors.

8.2 Recommendations for future research

After conducting this study, ideas for future research came forward to further develop the possibilities for improvements of the KAS of circular and sustainable water governance in Amsterdam as well as possibilities for improvement of other KASs. These recommendations for future research are provided below.

The study did provide insights into features of the KAS in the specific context of Amsterdam on circular and sustainable water governance. To further improve this KAS, the action research can be expanded into more actions within the 'Innovation in Watergovernance' program. The action research in the present study was far from comprehensive, and therefore better and more efficient methods can possibly be found. These can be aimed on the same targets of the current study, but also on other identified bottlenecks of the KAS. For example, by finding out how knowledge can better be captured to reduce the loss of valuable new generated knowledge in the KAS. Within these studies, attention must be paid to reduce the limitations that were present within the current study. A longer study time would be valuable to be able to evaluate a better impact of the actions. Moreover, actions should be conducted with more commitment from the researcher to ensure that studied actions are optimally performed.

Besides research within the program, it is valuable to explore and further develop the concept of KAS beyond the program. For this, further expansion is needed of the KASA framework concepts and operationalization. More research that applies the KASA in different contexts that face a challenge could therefore be helpful, such as different topics on technical innovation management in the health care sector (Fletcher & Payne, 2017; Straus, Tetroe, & Graham, 2011) or the transition towards sustainable transportation (Farla, Alkemade, & Suurs, 2010). Also, when the KASA is applied in different contexts, it may be possible to identify different types of KASs. By identifying different types, it moreover may be possible to link specific actions for improvement to different KAS types.

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Annex 1 – Small Survey [Dutch]

Achtergrond

Het Kennisactieprogramma Water is begin van start gegaan om water in de stad Amsterdam samen vernieuwend te organiseren. De circulaire stad is een van de nieuwe ideeën om duurzaamheid van water te stimuleren. Aanvullend op technische innovaties die nu al in living labs en proeftuinen door heel Nederland ontwikkeld worden, richten wij ons specifiek op het versterken van waterbeheer door vernieuwing in (1) de bestuurssystemen en (2) de ondersteunende kennisinfrastructuur.

Samenwerking tussen verschillende partijen staat centraal in het Kennisactieprogramma Water. Deze enquête is een eerste stap richting het verbeteren en aanvullen van het kennissysteem rondom de waterketen in de stad, zodat dit optimaal kan presteren. We willen bouwen aan een netwerk waarin kennis de centrale en gemeenschappelijke factor is. Met het invullen van deze korte survey kunt u ons helpen inzicht te krijgen in uw werk en uw rol binnen het bestaande kennissysteem. Graag vragen wij u ook naar specifieke namen/nominaties voor het uitbreiden van dit netwerk.

Persoonlijke Achtergrond

Naam:

Bedrijf/Werkgever/Organisatie:

Werklocatie:

Functie:

Bijdrage Kennissysteem

Vanuit welke hoek levert u uw bijdrage aan het kennissysteem op het gebied van water in de stad? [Meerdere opties mogelijk]

- Onderzoek
- Beleid of openbaar bestuur
- Praktijk / technologie
- Ik lever geen bijdrage aan dit kennissysteem
- Anders: …

Wat voor bijdrage levert u op het gebied van kennis? [Meerdere opties mogelijk]

- Nieuwe (wetenschappelijke) kennis genereren
- Kennis uitwisselen
- Kennisvragen agenderen / onderzoek uitzetten
- Beleidsbeslissingen maken op basis van kennis
- Beleidsadviezen geven op basis van kennis

- Lokale initiatieven opzetten en praktijk kennis onder de aandacht brengen
- Uitvoering van beleid in praktijk
- Anders: …

Kies de beste optie die voor u van toepassing is:

- Alleen een kennisproducent
- Meer kennisproducent dan kennisgebruiker
- Evenveel een kennisproducent als gebruiker
- Meer kennisgebruiker dan kennisproducent
- Alleen een kennisgebruiker
- Geen van beide

Kennisinhoud

Met welke kennisgebieden heeft u de meeste ervaring/komt u het meest mee in aanraking?
[Meerdere opties mogelijk]

- Natuurwetenschappelijke of technologische kennis
- Sociaalwetenschappelijk kennis
- Anders, namelijk: …

Met welk type kennis heeft u de meeste ervaring/komt u het meest mee in aanraking? [Meerdere opties mogelijk]

- Wetenschappelijke kennis
- Praktijkkennis of ervaringskennis
- Bestuurlijke/politieke kennis
- Anders: …

Kennis Visie

Welke van de volgende stellingen omschrijven de visie <u>binnen uw organisatie</u> het meest wat betreft kennisontwikkeling?

"Het is alleen de taak van onderzoekers aan universiteiten en wetenschappelijke instituten om nieuwe kennis te ontwikkelen. Andere partijen kunnen deze kennis gebruiken."

- Helemaal mee eens
- Een beetje mee eens
- Neutraal
- Een beetje mee oneens
- Helemaal mee oneens

"Het is de taak van alle partijen in de stedelijke waterketen om kennis te ontwikkelen en al deze partijen dragen hieraan bij. Deze kennis kan door iedereen gebruikt worden."

- Helemaal mee eens
- Een beetje mee eens
- Neutraal
- Een beetje mee oneens
- Helemaal mee oneens

Kennisbron

Van welke personen heeft u in 2016 het meest kennis verkregen op het gebied van water in de circulaire stad?
Personen: [Open tekst]

Van welke organisaties heeft u in 2016 het meest kennis verkregen op het gebied van water in de circulaire stad?
Organisaties: [Open tekst]

Welke personen hebben (naar uw weten) in 2016 het meest van uw kennis gebruik gemaakt binnen het gebied van water in de circulaire stad?
Personen: [Open tekst]

Welke organisaties hebben (naar uw weten) in 2016 het meest van uw kennis gebruik gemaakt binnen het gebied van water in de circulaire stad?
Organisaties: [Open tekst]

Functioneren Kennissysteem

Heeft u het gevoel dat u soms relevante kennis mist, die voor u van belang had kunnen zijn? Kies de beste optie die voor u van toepassing is:

- Ja, ik zou soms graag meer kennis willen maar ik weet niet precies waar ik die kan vinden
- Ja, ik zou soms graag meer kennis willen maar de kennis die ik nodig heb, kan ik niet bereiken
- Het zou best kunnen dat ik relevante kennis mis, maar ik ben mij hier niet van bewust
- Nee, ik kan altijd de juiste relevante kennis vinden die ik nodig heb.

Heeft u het gevoel dat uw bijdrage in het kennissysteem voldoende erkend wordt door andere instellingen? Kies de beste optie die voor u van toepassing is:

- Ja, mijn bijdrage wordt vaak gebruikt door andere partijen. Ik zie vaak resultaat van mijn bijdrage.
- Ja, mijn bijdrage wordt erkend, maar ik zie niet vaak direct resultaat van mijn bijdrage.
- Het zou best kunnen dat mijn bijdrage voldoende erkend wordt, maar dit weet ik niet zeker.
- Nee, mijn bijdrage wordt vaak niet erkend door andere partijen. Mijn bijdrage wordt niet voldoende op waarde geschat.
- Nee, mijn bijdrage wordt vaak niet erkend door andere partijen. Dit komt doordat mijn bijdrage al in eerste instantie moeilijk terecht komt bij andere partijen.
- Anders: …

Wat is volgens uw perceptie een gebrekig punt van de huidige en bestaande kennisinfrastructuur rondom water in de stad? [Meerdere opties mogelijk]

- De agendering (inhoudelijke focus) van kennis
- De kennis creatie
- De kennisuitwisseling
- Waardering van verschillende soorten/type kennis

- De kennisimplementatie
- Er is geen gebrekkig punt
- Anders, namelijk:

Netwerk

Zoals in de inleiding genoemd, zijn wij ook benieuwd naar specifieke namen ter uitbreiding van ons netwerk. Daarom vragen wij u na te denken over vijf mogelijke kandidaten (uiteraard: meer is welkom).

De volgende vijf personen zijn relevant om te betrekken in het kennisnetwerk op het gebied van water in de stad: (denk aan zowel praktijkkennis, bestuurlijke/politieke kennis, als academische kennis)
[Open tekst]

In april zal er een eerste bijeenkomst worden gehouden om het programma 'Vernieuwing in Watergovernance' nader te introduceren, en de eerste resultaten te bespreken. Op deze bijeenkomst hopen wij een representatieve vertegenwoordiging van het kennissysteem rondom de toekomst van water in de stad bij elkaar te brengen.

Welke personen zouden we volgens u zeker moeten uitnodigen voor deze bijeenkomst?
[Open tekst]

Feedback

Heeft u verder nog opmerkingen over deze enquête of over het programma 'Vernieuwing in Watergovernance'?
[Open tekst]

Annex 2 – Interview guide (KAS assessment) [Dutch]

Introductie

- Welkom.
- Vraag om goedkeuring voor het opnemen van het interview. De opname zal gebruikt worden om een transcript te maken van het interview. Een samenvatting van het interview zal nog terug gestuurd worden voor feedback.
- Leg het doel van het onderzoek en interview uit.

Het doel van het onderzoek is om het kennis-actie systeem van watermanagement rondom het thema water in een toekomstig circulaire stad Amsterdam te onderzoeken. (Een kennis-actie systeem is het systeem van kennis opdoen, kennis uitwisselen en kennis implementeren). Hierbij als doel het verbinden van verschillende partijen en het verbeteren van de overdracht van kennis naar actie. Daarbij is van belang om eerst het huidige kennissysteem in kaart te brengen. We zijn daarom op zoek naar verschillende partijen die een rol spelen in het kennissysteem en deze te ondervragen hierover. Hiermee hopen we een beeld te krijgen van de huidige situatie.

- Interview zal ongeveer 30 minuten duren.
- Vraag of er nog vragen zijn voor het interview start.

Achtergrondinformatie

1. Wat is uw functie binnen uw organisatie?

2. Wat doen jullie als organisatie? (Is er een unieke eigenschap?)

Bijdrage kennis

3. Hoe zou u uw rol in het kennissysteem van water in een circulaire stad Amsterdam omschrijven?

4. Met welke type kennis heeft u dan het meest te maken?
    - Genereert of gebruikt u kennis? (Uitwisselen van..? Doorgeven van..?)

Kennisnetwerk

5. Wat zijn in jouw belevenis belangrijke knelpunten van het kennisnetwerk?

6. Hoe zit dit met de kennis agendering (inhoudelijke focus), dus het uitzetten van kennis generatie en ontwikkeling van kennis?

7. Wordt er voldoende kennis gegenereerd of heeft u het gevoel dat dit onvoldoende is? (is er kennis die u mist?)

8. Wat is uw visie op de huidige mate van kennisuitwisseling tussen partijen?
    - Hoe zit dit bij u?

9. Is er voldoende waardering voor verschillende soorten/type kennis tussen (en binnen) verschillende actoren.

10. Hoe ervaart u op dit moment de kennisimplementatie?
    - Ziet u hier obstakels?

Ervaring met Kennisnetwerk

11. Ervaart u soms belemmeringen in uw functie/initiatief door aspecten rondom kennis (netwerk)?
    - Hoe speelt u hierop in?

12. Is het makkelijk voor u om kennis te delen met anderen? En te verkrijgen?
    - Geschikte partijen?
    - Erkenning?

Actoren identificatie

13. Zijn er soortgelijke organisaties als u?
    - Wordt daar kennis uitgewisseld?

14. Is het van belang dat er meer diverse actoren binnen het kennissysteem komen dan huidige situatie?

15. Van welke mensen/organisaties bent u afhankelijk in uw functioneren / bereiken van uw doel?

Connectie met andere actoren

16. Hoe zou u uw band met 1.overheid / 2.wetenschap / 3.praktijk omschrijven?
    - Waar kan deze van profiteren van u?
    - Waar heeft u deze partij voor nodig?
    - Hoe werkt u hier nu mee samen?

17. Zijn er andere sectoren interessant (bv. buitenland / energie)?
    - Werkt u samen met andere sectoren?

Visie

18. Wat is uw visie voor de toekomst van watermanagement in Amsterdam wat betreft water in een circulaire setting?
    - Is er een noodzaak tot circulaire economie?
    - Hoe kan een goede governance hieraan bijdragen? In welke vorm?
    - Waar moet de focus liggen voor onderzoek?

19. Loopt u tijdens uw werk aan tegen mensen met andere visies dan de uwe?
    - Levert dit problemen/knelpunten op?

Visie op KAS

20. Hoe kan volgens u een kennis-actie netwerk verbeterd worden rondom watermanagement in een circulaire stad?

Afsluiten interview

- Geef korte samenvatting met belangrijkste bevindingen
- Zijn er nog vragen/aanvullingen/suggesties?
- Bedank voor het interview

Annex 3 – Outline of the Knowledge Workshops 1 and 2

Knowledge Workshop 1

9.00am	Walk-in with coffee
9.30am	Opening (by chairman)
9.35am	Explanation of the 'Innovation in Watergovernance' program (by leader work package 5)
9.45am	Short presentation: The governance implications of promising techniques for decentralized water treatment (by leader work package 2)
9.55am	Table discussions ('world café') in two rounds [in between table change – fresh coffee]
10.40am	Inventory of outcomes per table
10.50am	Short presentation: The knowledge action system 'Water in the circular city' (by leader work package 4)
11.00am	4 parallel brainstorm sessions on the approach of the 'Innovation in Watergovernance' program (2 rounds of 20 minutes)
11.45am	Plenary feedback: inventory of action points
12.00pm	Closure: begin of lunch

Knowledge Workshop 2

17.00pm	Inloop met postersessie
17.30pm	Opening (by chairman), panel discussion with: member board management AGV, practitioner (SME) and leader work package 1
18.00pm	Table discussions ('World café'), with homogeneous groups of managers, policymakers, researchers and practitioners, about images and visions for the future around resources within the circular city. Focus on governance (task divisions, responsibilities and business models).
18.30pm	Dinner + change: mixing the groups
18.45pm	Table discussions ('World café'), with mixed groups. The different images and visions for the future, developed in the previous round, are shared with others from other domains. Focus on the comparison and understanding of each other's view.
19.15pm	Reflection and conclusions from the different tables and special attention for the members of the opening panel discussion
19.45pm	Closure: with invitation Knowledge Workshop 3 (autumn 2017)

Annex 4 – Evaluation Questionnaire Knowledge Workshops [Dutch]

Tick to what extent you agree with the following statements.

Tijdens de kenniswerkplaats Water:	Disagree	Neutral	Agree
heb ik nieuwe kennis of inzichten opgedaan			
heb ik nieuwe mensen leren kennen			
heb ik mijn visie kunnen delen			
heb ik kennis kunnen delen			
sprak ik mensen met een andere visie			
is mij duidelijker geworden wat er nodig is voor transitie naar een circulair systeem			
ben ik aangespoord tot verdere actie			
werkten we samen aan de toekomst			

De reden van mijn komst naar de Kenniswerkplaats Water was:

Het meest waardevol aan de Kenniswerkplaats Water vind ik:

Een minder goed punt van de kenniswerkplaats Water vind ik:

Mijn tip voor een volgende Kenniswerkplaats zou zijn: