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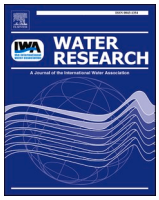

Exploring total economic values in an emerging urban circular wastewater system

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ABSTRACT

Circular water management has the potential to close resource and material loops within and across value chains. In the water industry, circular municipal wastewater management through industrial urban symbiosis (IUS) is recognized as a solution to overcome water scarcity in urban environments. IUS involves collaboration between actors with different organizational backgrounds, which can lead to inherent risks of conflicting goals. This study explores how different values drive various organizations to participate in an emerging circular wastewater collaboration. The study comprises a literature review of 34 scientific articles and a case study of a potential circular wastewater system through IUS in Simrishamn, Sweden. It presents an interdisciplinary framework based on the total economic value concept and organizational archetypes for examining actor values in circular wastewater management. This framework provides a novel approach for assessing different values and how they may compete or align. It can also identify the absence of certain values, enabling the achievement of a minimum level of value coherence amongst different actors, and thereby increasing the sustainability and effectiveness of circular wastewater collaborations. Therefore, careful planning and stakeholder interaction, in accordance with economic value perspectives, can enhance the legitimacy and policy development of circular solutions.

1. Introduction

Freshwater is a vital necessity for both ecosystems and society (Bunsen et al., 2021). Water is also a key driver of social and economic development, as it is critical for agriculture and industrial production (Bunsen et al., 2021; Cosgrove and Loucks, 2015). However, climate change and the persistent increasing trend of polluting the aquatic environment continues to put increasing pressure on global water resources (Delpla et al., 2009). Environmental change is impacting the hydrological cycle across all scales, from local water sources to regional climate systems, in turn affecting the Earth's capacity to adapt to changing conditions and situations of crisis (Falkenmark et al., 2019). Moreover, water demands are continuously increasing in order to support growing populations, urban expansion, rising energy demands and industrial needs (UNEP, 2021). The challenges are compounding and it is estimated that by 2030 (with current water and sanitation management practices) around 2.2 billion people will lack sufficient access to safe drinking water, and 4.2 billion people will lack access to safe sanitation (FAO and UN Water, 2021). Even though European countries are not amongst the most seriously affected, the European Commission states in a 2019 report that less than half of the EU's waterbodies are in a good condition (European Commission, 2019).

Despite the recent commitments made by many countries, and despite the fact that global water-use efficiency has increased in recent years, there is still an urgent need to improve how we use and manage water (FAO and UN Water, 2021; UNEP, 2021). There are strong links between sustainable development goal number six (SDG6, clean water and sanitation) and the circular economy when it comes to developing sustainable water practices (Bakan et al., 2021; Schroeder et al., 2019). For instance, the UN has identified integrated water resource management (IWRM) as a significant approach in order to match water demand (across actors and across sectors in society) without compromising the ecosystem (UNEP, 2021). IWRM and circular wastewater concepts strive to maximize economic and social welfare, while assuring access to finite water resources (UNEP, 2012). The concepts largely build upon participatory processes and stakeholder engagement, in order to generate cross-sectorial policy approaches and develop sustainable water management solutions. The awareness that water is an elemental component of the ecosystem as well as a social and economic good stress the point that water contains various perceptions of value. Even though

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management of water resources is a critical factor for urban sustainability, the reality is that it is often difficult for water service providers to deliver quality services that live up to both regulations and budget constraints (Marlow et al., 2013).

One way of advancing sustainable water management is the implementation of wastewater reclamation. This can be done through circular approaches, such as industrial symbiosis, reducing abstraction and freshwater use for various economic applications (e.g. agriculture or industrial production). Another way of improving water access is by aquifer recharge. Unfortunately, progress has not been sufficient, and efforts need to double if the goal of broad implementation of IWRM by 2030 is to be achieved. Industrial symbiosis collaborations have been proposed as a potentially important component in sustainable business models (Fraccascia et al., 2019) and are suitable for circular water management (Patala et al., 2020). The UNEP (2021) states that some of the major challenges in implementing IWRM are insufficient financing and poor coordination amongst water-related initiatives, weak policy alignments and a lack of coordination between water-related sectors and stakeholders. The results in this study indicate that the most frequently identified economic values in circular wastewater systems relates to direct use values. This means for example monetised market values for irrigation or other forms of monetised values from using water directly. Other frequently identified values in this study are indirect use values and *in situ* values, for example ground water injection and recreational activities. A policy implication from the results is that direct and indirect use values are important, but other (non-use) values should be considered when implementing IWRM.

Projects to develop wastewater synergies are being funded under the European Commission's research programme Horizon 2020. Despite these initiatives, there is insufficient knowledge regarding innovation and business models for implementing new technologies in urban water management operations (Sousa-Zomer and Miguel, 2018). There is also a lack of studies with a clear focus on IWRM (e.g. circular water management arrangements or industrial symbiosis collaborations) and organisational perspectives of value. Moreover, despite the expected benefits (for example through industrial symbiosis) that might incentivise circular water treatment, challenges to effective implementation still remain (Södergren and Palm, 2021b). Although a few recent studies (Gregg et al., 2020; Ramsheva et al., 2019; Södergren and Palm, 2021a) have analysed value in relation to different social actors, they offer limited insights into organisational perspectives and rationales. Additionally, it has been shown to be challenging to ascribe value or provide measures of benefits to environmental functions and services that are not priced by market mechanisms (Langford et al., 2001; Wadström et al., 2021). Thus, there is a lack of studies discussing the essentials of value and how this relates to different organisations and stakeholders involved in an emerging industrial symbiosis (Södergren and Palm, 2021b).

In order to bridge this knowledge gap, this study first critically examines how value – according to economic theory – is viewed and implemented in water management research. Next, the study presents a descriptive case study that investigates which values are driving different types of organisations and actors engaged in an emerging circular wastewater collaboration project. The structured literature review of 34 scientific articles provides important details and valuable context in order to effectively interpret and generalise the findings from the case study. The case study takes place in the municipality of Simrishamn in Sweden, where a full-scale system for advanced water treatment has been operational since the beginning of 2019. The treatment facility is capable of removing micro pollutants such as pharmaceutical and hormone-disturbing substances. An evaluation of the plant and the reusability of the treated water showed that the removal rate for pharmaceuticals, endocrine-disrupting substances and antibiotics was almost 100% (Christian Baresel et al., 2020). The considered circular water synergy in Simrishamn includes the reuse of water in industry, agriculture, and groundwater injection.

The study applies qualitative content analysis (QCA) as its main analytical method and uses the concept of total economic value (TEV) and organisational theory for the construction of the coding frame used in the formal analysis. The purpose of the analysis is to identify links between theory and empirical findings in a comprehensive approach to understanding value perceptions related to circular wastewater management. By mapping and analysing which values are in focus for different organisations, this can contribute to understanding why more circular water management arrangements are not implemented. The research questions addressed by the literature review are:

- With regard to water management and circular water management, what is the object of the study?
- Which actors and organisational archetypes are studied?
- In accordance with TEV, and from an organisational perspective, which value classes are identified and expressed in the research?

In the case study, the following research question is addressed:

- Which values are expressed by different organisations taking part in an emerging circular water reclamation collaboration, and how do these values converge or diverge?

To the authors knowledge, there are no previous studies in sustainable water literature that uses the combination of TEV and QCA. The application of TEV is often limited to the inclusion of use values, often in the form of market prices, and non-use values are often loosely ascribed to perceptions of individuals in various cost-benefit analysis approaches (Birol et al., 2010). In this study, definitions and classifications are clearly and explicitly stated, and are then used to critically explore which values are expressed. This ensures valid and reliable results. By using QCA, and by deductively classifying values according to TEV and organisational theory, it will be possible to both generalise and compare the results across cases, organisations, and situations. This study introduces a novel approach to TEV analysis, which goes beyond identifying spatial effects and delves into temporal effects as well. This means that it can provide insights into when a specific value contributes, the nature of that value, and which actor or organization it is most relevant to.

This will provide a better understanding of the incentive structure around which values are typically included or excluded in a circular wastewater collaboration scheme. It will also provide insights into how different values either compete or align, as well as how this may impact the realisation and continuation of the circular wastewater system. For instance, it can reveal how the value of a circular solution changes over time, how different stakeholders are affected, and who stands to benefit or lose from changes in the value. Moreover, this framework's ability to identify the nature of the value in question provides a more nuanced perspective on the various benefits and costs associated with a particular activity or policy. It can uncover hidden costs or benefits that are not immediately apparent in traditional analyses and reveal the true trade-offs involved in decision-making.

The terms circular wastewater management and circular wastewater systems are used interchangeably in this study, as both terms consider the circular use of wastewater. We also refer to wastewater symbiosis and wastewater collaboration, as both concepts highlight multi-actor engagement, participation, and cooperation. The limitation with the study is that it is a single case study, which can give an analytical rather the statistical representative contribution. Another limitation is that the study does not cover the full range of value perspective existing, but has a narrower scope where value classes are related to TEV and the chosen organisational perspective.

The paper is structured as follows. In Section 2, the theoretical chapter explores the fundamentals of the economic concept of TEV and the organisational archetypes in wastewater treatment. Section 3 presents the method for data collection and analysis. Section 4 contains the

results from a literature review and a case study. The paper ends with a discussion in Section 5, where the review and case study are compared. Conclusions and key takeaways, as well as ideas for moving the research field forward, are presented in Section 6.

2. Theory

The total economic value (TEV) approach used in this paper incorporates the concept of non-use values. This value class is important but also controversial (Cummings and Harrison, 1995). Unlike use values, non-use values are separated from any present or expected future utility of an object or resource and its provided services, for example the willingness to pay to preserve a river even though no one may ever use it. While the concept of non-use values, such as existence value, are widely accepted, the controversy lies in the issue of how to measure them and discern non-use values from the total economic value (Crowards, 1997; Cummings and Harrison, 1995; Kotchen and Reiling, 2000; Schultz et al., 2012). Even if the debate on the role of non-use values is intriguing and important, the main goal of this study is not to contribute to the debate itself. Rather, the ambition is to use the concept of total economic value as a framework for identifying value perceptions in different organisational archetypes taking part in a wastewater symbiosis. Understanding specific perspectives of value may prove essential when translating these into real incentives (Engel et al., 2008), in order to provide circular urban water services. This has been a starting point for this study.

2.1. Value in economic theory

As humans, we are constantly making choices, either individually or collectively, and choices are an unescapable and central part of our lives. Some choices constitute major decisions, while other choices are routine (Champ et al., 2003). All choices involve evaluating alternatives, as choosing one option precludes choosing other options (Gold and Shadlen, 2007). Nonmarket valuation is basically about analysing value based on individual choices that are not fully captured by market mechanisms (Champ et al., 2003). Furthermore, the process of making choices is essentially an assessment of individual preferences over a set of options. Conversely, this means that choices reveal information about preferences (Champ et al., 2003; Von Neumann and Morgenstern, 2007). Standard economic theory describes value as a form of measure for the trade-offs that individuals are willing to make. The total economic value (TEV) framework, presented for example by Pearce and Turner (1990) and illustrated in Fig. 1, describes and organises different classes of value that we will associate with circular wastewater collaboration. In this paper, value is divided into two general classes: Use value and Non-use value. For detailed definitions of how values are coded, see Table 1.

Use value is the broader class of values that originate from the actual use of water. Use value includes direct use value, indirect value and option value. Direct use values include consumptive and commercial value, where water is used either directly in production or as the output. Furthermore, direct use value can also be derived from non-consumptive, *in-situ* use of the resource or service (e.g. recreation or swimming).

Indirect use value comprises the utility that a person might derive from an asset without actually using the asset itself (e.g. pollination by bees and maintenance of oxygen cycles by plants). This study takes a humanistic and consequential approach, which is why, for example, ecosystem services are coded as indirect value.

Option value is not associated with the current use of a resource or environmental asset. Instead, this value is derived from the possibility of using the resource at some later date. This is typically measured as the value attached to future development or use opportunities, and does not need to be exclusively related to either consumptive or non-consumptive use (Henry, 1974; Weisbrod, 1964). In other words, option value can be viewed as an "extra payment in order to ensure future availability".

A non-use value is derived distinctively, independently from the direct or indirect use of an asset, environment or service. A non-use value can be either existence value or bequest value, where the first value class stems from the knowledge that a particular species or environmental asset simply exists, and the latter from the individual desire to pass on a certain (environmental) asset to one's heirs or to preserve it for future generations (Crowards, 1997).

Quasi option value describes the welfare gain associated with delaying a decision where there is uncertainty about the future payoffs and alternative choices. In order to evaluate quasi option value, at least one of the choices must involve an irreversible change and commitment of the considered resources. Quasi option value arises from the value of information gained by postponing an irreversible decision to develop a natural resource or environmental asset (Fisher and Hanemann, 1987). For example, the value gained from delaying a decision to develop a freshwater resource, where the future value of preservation is unknown until a future date. In this paper, quasi option value is placed between use and non-use value, as it can be considered as both, depending on the actual outcome.

2.2. Organisational archetypes in wastewater reclamation

Different organisational archetypes bring or encompass different core values. In order to more deeply understand the values expressed and promoted by different forms of organisations, a basic understanding

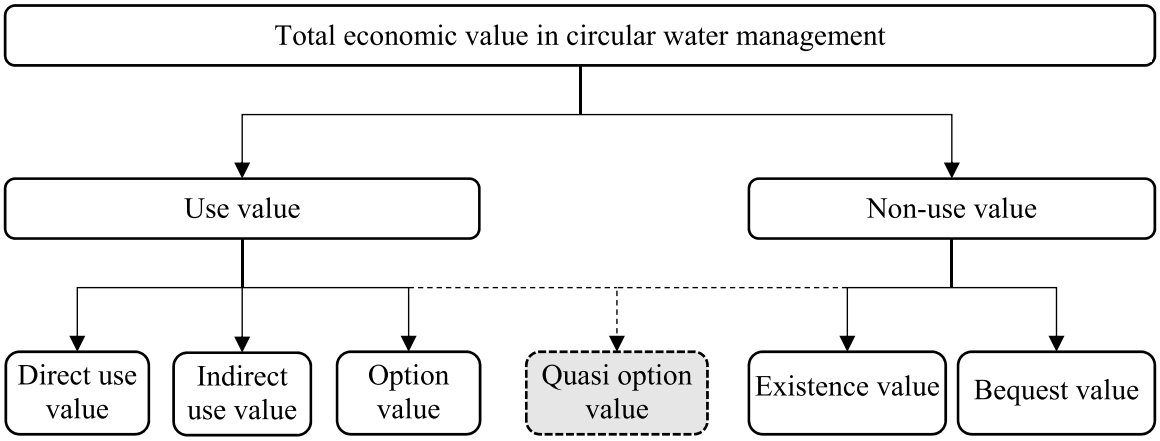

Fig. 1. Decomposition of the total economic value concept used in this study, based on works by Pearce and Turner (1990), Krutilla (1967), Fisher and Hanemann (1987), and Henry (1974). The dashed line indicates that in this study quasi option value can conceptually belong to either use values or non-use values.

Table 1
Coding frame for deductive categories of value classes.

Category	Description	Explanation/example	Coding rule
Use value	Use value is defined as the broader class of values that originate from the actual use of water, including direct use value (including *in-situ* non-consumptive use), indirect value and option value.	This category will also include some inductive coding containing subcategories for more detailed results. E. g. negative direct use values are not related to costs (operational, maintenance or investment cost etc.) – they are more related to disbenefits.	E.g. positive/negative externalities coded as indirect use values and negative direct use value. (Negative direct use values ≠ costs.)
Direct use value	Focus on the direct use of the resource (here, recovered/treated wastewater). Direct use value includes consumptive commercial value, where water is used in combination with other production factors and the output is marketed. Also included in this category is *in-situ* use value.	Commercialised products and consumption activities **directly** related to the synergy. Thus, any mention of value generated by reused or recirculated wastewater that is directly used as an input factor will be coded into this category. Non-consumptive *in-situ* use value such as recreational activities in, on or near object of study.	E.g. irrigation for fruit and vegetables; direct water use in production of textiles and garments; and electricity or the non-consumptive, *in-situ* use value arising from direct use of the resource or service (e. g. recreation or swimming).
Indirect use value	Benefits derived from the goods and services provided by the symbiosis, that are used indirectly by an entity. For example, secondary effects and if an entity at some distance from the synergy may derive benefits from the water in some way as it passes through the system.	Content assigned to this category must refer to values **not** related to the direct use of circular water. E.g. values/effects impacting ecosystem services or related indirect activities. Also, indirect values can consist of externalities (both positive and negative).	E.g. referring to recirculation or replenishing groundwater or improving water ecosystem services will be coded as indirect use value. Other examples are increased employment as secondary effects and externalities. Content explicitly stating saving water for future direct use will be coded as option value, but otherwise replenishing or returning will be coded as indirect use value.
Option value	Option value is associated with the future use and not the current use of a resource or environmental asset. The value derives from using the resource at some later date.	Must be a clear reference to a future value. In order to achieve excludability, all segments regarding use value but **NOT** containing a clear reference to a future use value will be coded as a direct use value. This also applies to potential innovations and new products, etc.	E.g. The option value for the municipality/ community from having access to water in the future. All mentions of value regarding limiting, e.g. future climate risk, sustainable water treatment and circularity, will be coded as option value.
Non-use value	Non-use value is assigned to goods even if the individual assigning the values never has and never will use it. Non-use value is distinguished from use value, which people derive from direct use of the good.	Non- use values can be associated with a positive (or negative feeling/disbenefit) feeling for a good/service (environment, ecosystem, biodiversity) For more examples see subcategories: Existence and Bequest value.	All explicit use of or mentioning of non-use values in the material will be coded to ither existence value or bequest value according to Fig. 1. The coding of other, vaguer, mentioning of non-use values should be done with care, in order not to overinterpret meaning of values mentioned.
Existence value	Existence value reflects the benefit people receive from knowing that a particular environmental resource exists. Existence value is an important example of non-use value, as it does not require any utility to be directly derived from the use of the resource. The utility comes from simply knowing that the resource exists.	Content expressing value from merely being aware of the existence of a resource (or closely related to the resource), sense of pride and joy in the resource, etc., will be coded into this category.	Negative existence value is inductively included in this subcategory.
Bequest value	Bequest value is the value of satisfaction from preserving a resource, a natural environment or a historic environment, for future generations. It can be used when estimating the value of an environmental service or good.	Content must refer to future generations and not include references to current or near future effects. Clear division between currently living generations and future generations (living organisms) not yet born.	Just as for categorising non-use values, in order to categorise a bequest value, there must be explicit mentioning's of bequest values or otherwise clear meaning. Examples: "for future generations" etc.
Quasi option value	Quasi option value is the value of information/ knowledge gained by delaying a decision to commit to some irreversible action.	This category is a little more loosely defined when coded. Any value that is intended to generate more knowledge in the future will be assigned to this category. All other forms of value stemming from deferring direct use to a future point in time will be coded as option value.	Segments to be assigned to this category must specifically refer to the value of investing in or suspending direct use on the basis of obtaining more knowledge or information for later use.

of their modes of governing is required. Since organisations taking part in circular wastewater systems such as industrial symbiosis are essentially separate entities, their management structures, strategies, cultures and values are likely to vary (Brinckerhoff, 2009; Tudor et al., 2007).

In governance literature, different organisational archetypes have been distinguished, including: hierarchy, market, network, hybrid and NGO (Niehaves et al., 2011; Pahl-Wostl, 2015; Palm et al., 2019a, 2019b; Tang and Zhan, 2008; Thompson, 2003).We will here discuss values in relation to these different organisation forms, but adapted to the wastewater sector. For detailed definitions concerning the coding, see Table 2.

"Hierarchy is a structured mechanism of control, designed to run large and complex organizations" (Thompson, 2003). The central idea is to control the hierarchical organisation through bureaucratic measures such as scrutiny, rulemaking, issuing orders, directives, monitoring and auditing. When there is control of the entirety, all parts can work for a collective purpose and result. A hierarchical structure of wastewater management typically translates into services being run by the municipal administration. The municipality thus organises the strategic planning and the operation of freshwater, Wastewater Treatment Plant (WWTP) and sewage facilities within the framework of municipal administration (Lingsten, 2010; Thomasson, 2013). The operational responsibility is often delegated to one municipal department, such as the Department for Civil, Environmental and Natural Resources.

A market is a mechanism that coordinates economic activities and ensures order without any detailed organising centre that directs it. In wastewater management, market-based governance is typically seen when private companies are in charge of water services. All management tasks, responsibilities and ownership of water utilities are placed in the hands of private operators. This is not so common, though, and in

Europe this only exist in England, Wales and the Czech Republic (EurEau, 2018). Within a circular water management scheme, such as an industrial symbiosis, the collaborative arrangements typically emerge through firms developing a self-organising network for resource exchange (Chertow, 2007). In the case studied in this article, it is the municipality that has brought companies together to start working on circular water management. The market actors in our case study are represented by the private firms invited to participate in the circular water management scheme.

A hybrid form of governance appears at the intersection between public administration (hierarchy) and private corporation (market), as there is a blending of logics, institutional orders and traits of character (Furusten and Alexius, 2019). In this context, it applies to delegated public management, where a management entity is appointed by the responsible public entity to execute the management tasks. In this case, it will be represented by a municipally owned water corporation. According to Furusten and Alexius (2009) the "blend of logics is perhaps most striking in the case of state-owned enterprises, since the logics of political control and civic value are mixed with the logic of profit-making".

The civic/NGO archetype is added as an alternative approach for analysing how activity is organised and governed. In the analysis, we will focus on the policy-advocacy-based NGOs which aim to influence policy and decision-making of governments, disseminate information and take action with other stakeholders (Kuruppu and Lodhia, 2019; Unerman and O'Dwyer, 2006). These archetypes tend to arise from for example smaller, bottom-up, civic or grassroots movements and by a deliberate design. They often rely on direct personal contact and are confined to a clearly defined group or interest. Network groups, such as civic/NGOs, tend to work through attributes like loyalty and trust rather than administrative orders or prices (Thompson, 2003). NGOs like WWF have played a significant role in water management globally (Van der Brugge et al., 2005).

In the case study analysis, the following four broad types are used in the coding: municipality, market producer, municipal corporation, and NGO.

3. Material and method

In order to develop an understanding of how value is viewed and expressed amongst different actors and stakeholders in a circular wastewater collaborations, the study applies QCA to primary data (semi-structured interviews) and secondary data (documents and scientific articles) gathered in the study.

3.1. Data collection review

The literature search was performed in January 2022 using the scholarly database Scopus. The study focuses on values in circular wastewater operations according to TEV. The search criteria used the following Boolean operators:

1. TITLE-ABS-KEY ("Total Economic Value*" OR "Use Value*" OR "Non Use Value*" OR "Direct Use Value*" OR "Indirect Use Value*" OR "Option Value*" OR "Quasi Option Value*" OR "Existence Value*" OR "Bequest Value*")

   AND

2. TITLE-ABS-KEY ("circular wastewater" OR "circular water management" OR "water management" OR "water reclamation" OR "wastewater reclamation" OR "integrated water resource management")

This specification concentrates the material in order for the analysis to specifically capture values that relate to circular water management. Fig. 2 presents the systems boundary for the search and inclusion criteria operationalised by the second set of Boolean operators. Furthermore, the search is limited to articles published in peer-reviewed journals and written in English. In order to be relevant for inclusion in the analysis, selected articles need to explicitly study a case of water management, real or hypothetical (see Fig. 3 for search query and selection criteria). For example, publications containing studies of water purifying techniques will be omitted. In the next step, the articles selected for full analysis were methodically read and then coded.

In total, 34 articles were analysed. The studied material included a wide range of different types of studies, such as assessments, frameworks, cost-benefit studies, contingent valuation, modelling, optimisation, simulations, principal component analysis, real options and various valuation studies. The analysed material was published between 1983 and 2021, and thus spans a long period.

3.2. Data collection for Simrishamn case study

Data was collected in multiple steps, with primary data collection via interviews and archival analysis being conducted between September 2019 and June 2020 in Simrishamn, a municipality located in the south of Sweden. During this period, the municipality was in the initial establishment phase of a circular wastewater collaboration through industrial symbiosis involving a variation of private and public stakeholders. Fig. 4 illustrates the system boundaries for the study and provides a visual representation of the different sectors involved in the emerging symbiosis.

Table 2
Coding frame for deductive categories of studied organisations and actors.

Category	Description	Explanation/example	Coding rule
Hierarchy (municipality)	Hierarchy: a structured mechanism of control, designed to run large and complex organisations.	Public (municipal) administration, government body,	All mentions of government agencies, regional or local authorities will be coded as hierarchy.
Market (market producers)	Coordination of economic activities without any detailed organising structure that directs participants.	Market actors and participants that satisfy their demand for marketable terms or actors supplying goods to a market. E.g. private companies, industry and agriculture, etc.	In the literature review, consumers, households and individuals in a population have been coded as market participants. Even if these actors are not an organisation per se, it is still the most fitting category in this study.
Hybrid (municipal corporation)	The intersection between public administration (hierarchy) and private corporation (market).	State-owned enterprise/public (municipal) corporation. E.g. wastewater treatment plants, etc.	National parks and public bodies such as universities and public projects have been coded as hybrid organisations.
Civic/NGO	An organisation or network that operates independently and seeks to influence policy and decision-making of governments, disseminate information and take action with other stakeholders.	The civic/NGO organisation works through attributes like loyalty and trust rather than administrative orders or prices. E.g. World Wildlife Fund, Clean Water Fund, Global Water Challenge, etc.	In the literature review, only explicit NGOs have been coded in this category.

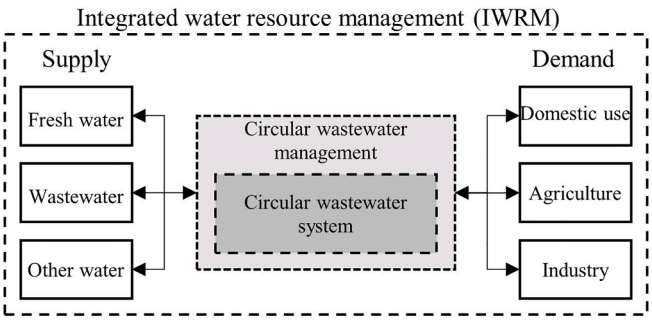

Fig. 2. System boundary for review search and inclusion criteria.

To obtain primary data, semi-structured interviews were conducted with 14 respondents (see Appendix A). These actors were identified after having conducted a stakeholder analysis together with representatives from the municipality, targeting organisations of relevance to this study. All organisations with clear a link to – or an interest in – developing a circular wastewater system through industrial symbiosis were included in the sample. five respondents were selected from the municipal organisation, three from the municipal water and sewage company, five from various private companies in the area, and one from an agricultural non-governmental organisation (NGO) representing farmers' interests. Interviews were recorded and transcribed into text files. For more information about the types of questions asked during the interviews, see Appendix B.

To complement the interview data, archival research was also conducted. Documents were gathered from the municipality as well as from the Water and Sewage Department. The documents contain information regarding decision-making processes linked to the strategic development of circular water management and the WWTPs located in Simrishamn. For details, see Appendix C.

3.3. Coding frame and analysis

Qualitative content analysis (QCA) is a systematic and flexible method for describing the meaning of qualitative data in a concise manner. It is suitable for material that requires some degree of interpretation. It can be applied to a broad range of data sources, including interview transcripts, company brochures, presentations, contracts, policy documents, articles, textbooks, websites, etc. (Elo and Kyngäs, 2008; Mayring, 2004; Schreier, 2012).

In this paper we followed a procedure for QCA proposed by Schreier (2012). Fig. 5 summarises the main steps included in this methodological approach: (1) research question, (2) selecting texts and documents, (3) developing the coding frame, (4) dividing the material into units of coding, (5) testing the coding frame and first coding, (6) evaluating and modifying the coding frame, (7) main analysis/second coding, and (8) interpreting and presenting findings.

The main component in a QCA is the coding frame because it controls how the material will be categorised and analysed. This study will mainly use concept or theory driven (deductive) categories in the coding frame. However, there will also be some elements of data-driven (inductive) categorisations. The deductive strategy used in this study mainly applies to the identification of values defined by the TEV concept (see Table 1 for details of our deductively derived categories and subcategories) and the identification of organisations (see Table 2 for details of.xpressed negative values or disbenefits in the studied material. Note that in this study, negative values are not to be equated with costs.

The review material was coded on two different occasions by one of the authors of this paper. The coding procedure incorporated marking and assigning specific words, phrases, or paragraphs into categories specified by the coding frame presented in Tables 1 and 2. The analysis focuses on the occurrence of various categories in each article, not the frequency of the occurrences. In this way, categories are all equally weighted and the results considers the occurrence of various value classes and the inductively identified categories presented in the result section. The repeated coding procedure, with a time gap of one week in between occasions, limits the risk of missing information in the material and increases the validity. The case study material was cross-coded by

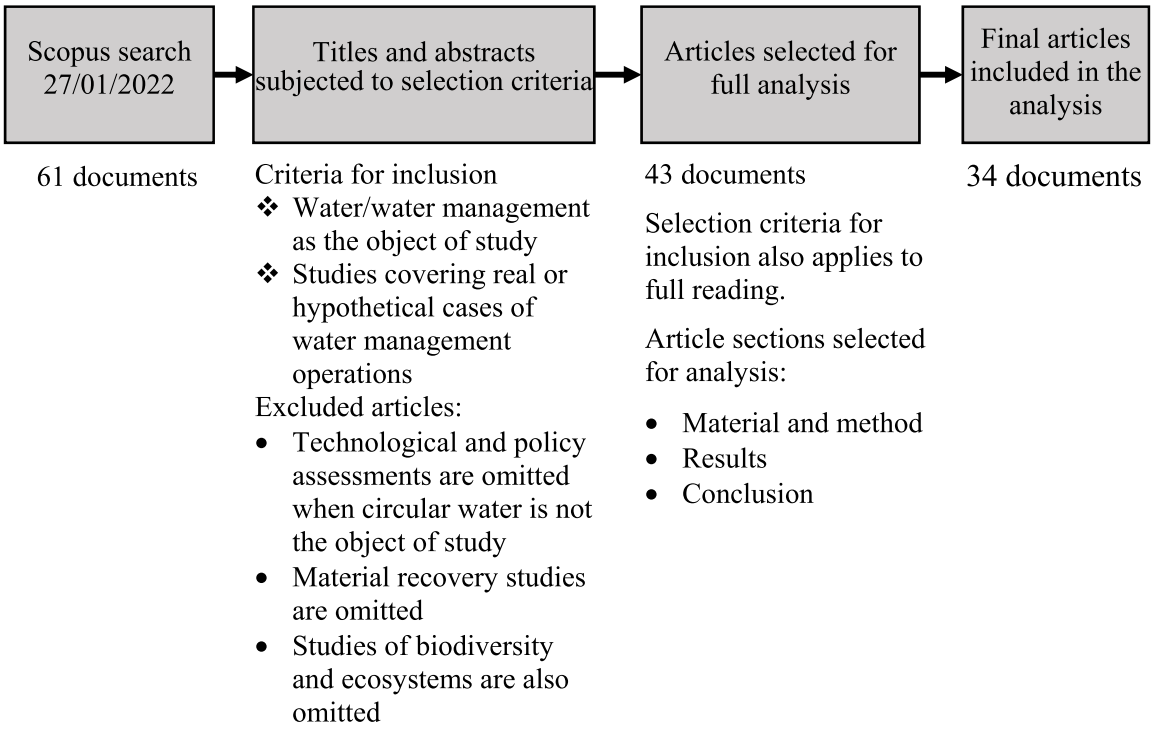

Fig. 3. Procedure for literature review.

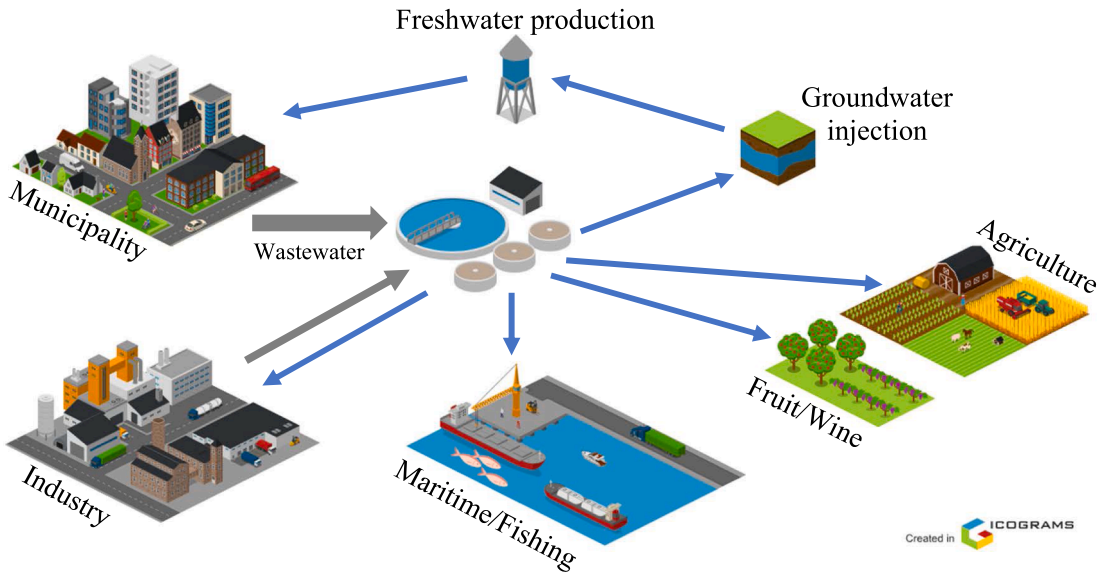

Fig. 4. Visual representation of sectors involved in the emerging circular wastewater collaboration through industrial symbiosis in Simrishamn.

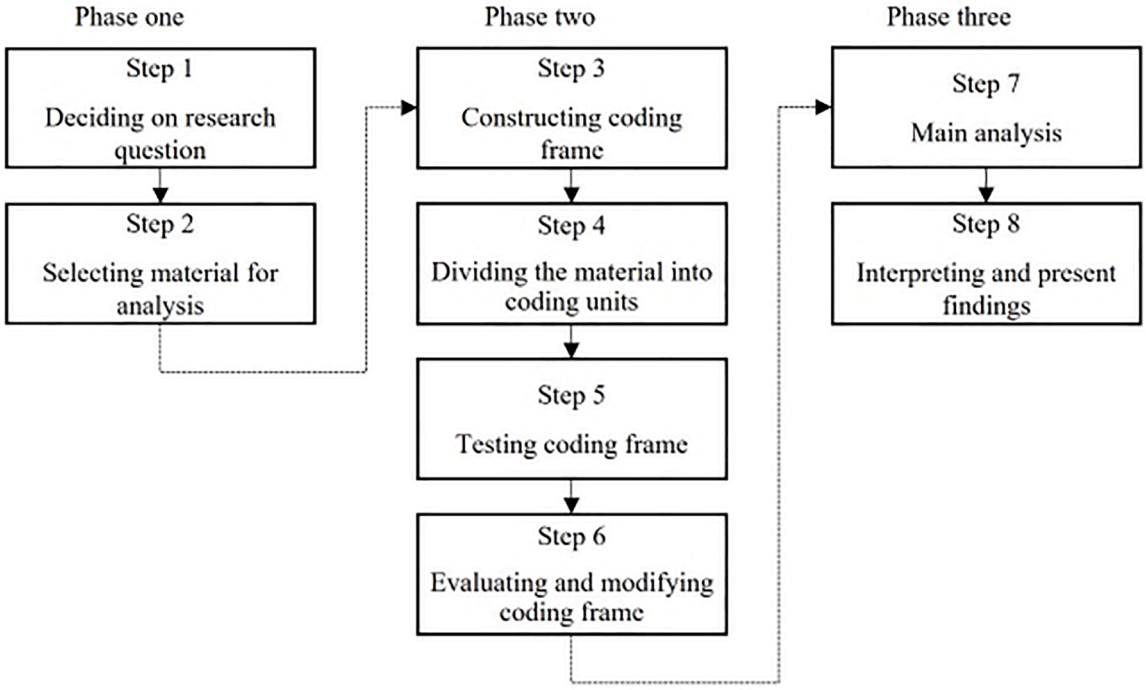

Fig. 5. An interpretation of the procedural steps in QCA presented by Schreier (2012, p. 6).

two of the authors. Both the review and the case study coding were performed using the computer software NVivo 12 Pro (QSR International Pty Ltd, 2020). Computer-assisted qualitative data analysis software (CAQDAS), such as NVivo, is useful when synthesising content across academic literature. It also allows for systematic coding and analysis of textual data across multiple categories (Curtis and Lehner, 2019). Furthermore, CAQDAS reduces human errors in the coding process (Escarcha et al., 2018), and when working with more than one coder it increase validity and reliability (García-Horta and Guerra-Ramos, 2009; Rademaker et al., 2012).

Each article, interview or document was first segmented into smaller parts (step 4), where the segments selected for coding have to be directly linked to questions that relate to water synergies, or circularity in the water and sewage sector. This strict segmenting criteria is implemented in order to ensure validity when coding, and to limit overinterpretation and the risk of coding out-of-context answers. In this way, the risk of wrongly including coded value classes is limited, but there is an increased risk of missing out on relevant content that should be included in the analysis. In order to control for this issue, all case study material was segmented individually by both coders and then compared in order to incorporate all relevant information in the material. The review material was segmented on both coding occasions, with a time gap of one week in between.

Next, the segments were coded according to the coding frame (step 5). After the initial coding, the results of the coding were compared (step 6). Cohen's kappa (κ) coefficient (Cohen, 1960) was used in order to ensure a high level of reliability. If the different coding results are in complete agreement the kappa coefficient is 1, and if there is no

agreement (other than by chance) the coefficient is 0. Coefficients between 0 and 1 mean partial agreement. Any category with a kappa coefficient below 0.7 was selected for revision and revised until the kappa coefficient for each category reached the threshold rate of at least 0.7, a level indicating high agreement between codings (McHugh, 2012).

4. Results and analysis

In order to provide a general understanding of value from the perspective of water management, Section 4.1 presents and analyses the results from the literature review (see Appendix D for references). Next, in Section 4.2, the case study results are presented separately and in detail.

4.1. Overall findings review

As can be seen in Fig. 6, earlier studies have identified and expressed a narrower scope of value classes. In these studies, mainly positive direct and indirect value classes were identified (e.g. Venkatesh and Hobbs, 1999).

4.1.1. Value classes from the perspective of the object of study

The majority of the analysed material (30 articles) studied geographical locations, water reservoirs or other specific types of water source (e.g. Dupont and Renzetti, 2008; McDonald and Johns, 1999). TEV in relation to circular water management was relatively unexplored. However, the few articles studying circular water management were also the only studies (Liu and Cheah, 2009; Segui et al., 2009) containing references to negative indirect use values (negative externalities). Fig. 7 shows that direct use values are the most common value class in the main body of the studied material (articles studying geographical locations and water sources such as lakes and reservoirs), in combination with *in-situ* direct use values. This could be attributed to the fact that the articles often study lakes and water reservoirs in, on or near which recreational activities can be studied and included in various valuation techniques. Indirect use values (positive externalities and secondary effects) were also expressed in the material (e.g. Okumah and Yeboah, 2020), with a few studies also mentioning option values (e.g. Liu and Cheah, 2009). The option values identified were mainly descriptive statements of option value, and some calculated option values related to e.g. conservation costs of reservoirs, natural parks and future access to direct use of water. Existence values and bequest values were also present, but these were mainly descriptive statements, along with stated preferences regarding the benefits from knowing that a water resource exists and that it will be enjoyed by future generations (e.g. Dadaser-Celik et al., 2009; Lowe et al., 2020).

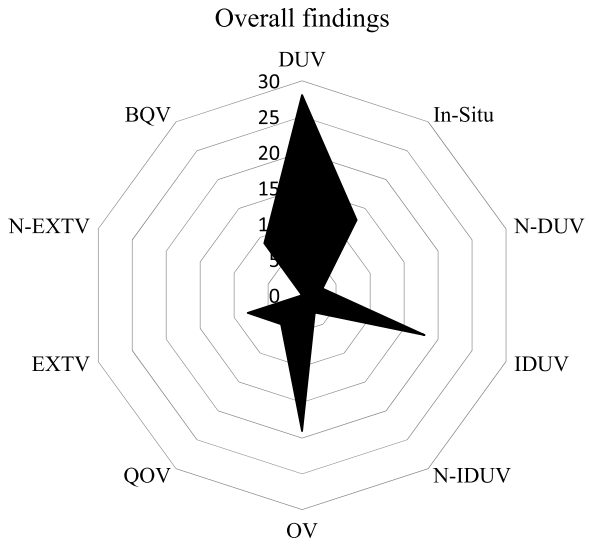

Fig. 6. Overall findings of the review. Identified TEV classes from the review of articles published between 1983 and 2021. Scale indicates the number of articles containing TEV classes as specified in coding frame (Table 1). DUV = direct use value, N-DUV = negative direct use value, IDUV = indirect use value, N-IDUV = negative indirect use value, OV = option value, QOV = quasi option value, EXTV = existence value, N-EXTV = negative existence value, and BQV = bequest value.

4.1.2. Value from the perspective of organisations

Fig. 8 shows the results analysed from the perspective of organisations. For the category market producers (agriculture, consumers or population, and industry), the structure of the identified value classes was almost identical. The majority of the identified values were direct use values (and *in-situ* use values) (e.g. Kondili et al., 2010; Lowe et al., 2020), followed by indirect (e.g. Berbel et al., 2018; Lado, 1997), existence value (e.g. Lado, 1997) and option value (e.g. Qureshi et al., 2012). Another result was that value, according to TEV, is not commonly studied when it comes to hierarchical and hybrid organisations. However, these organisational perspectives did include negative indirect values, for example negative externalities in the form of harm to the environment.

4.2. Simrishamn case study results

The results are summarised in Figs. 9 and 10, showing that respondents mainly referred to direct and indirect use values when discussing wastewater synergies or symbiosis. The results are based on explicit comments made by interviewees or by explicit statements in the studied documents. This could be an indication that the involved organisations mainly viewed the development of circular water schemes as a process of commercialising wastewater as a resource (Bakker, 2002). In the interviews, all classes of value are expressed, although to varying degrees. Besides direct and indirect use values, option and quasi option values were the most commonly occurring value classes. Furthermore, there were occasional statements expressing negative existence value. However, there were very few such occurrences. When analysing written documents, the content emphasises indirect use value over direct use value, and there were no occurrences or mentions of existence value. Bequest value only occurred infrequently in both interviews and documents. A coherence in expressed values might be an indication of that the process of developing circular wastewater management is characterised less by conflict and more by consensus in relation to how resources should be shared and how to organise a symbiosis (Brown et al., 2017). For examples of coded interview quotations, see Appendix E.

Considering respondent organisational belonging, the material indicates that respondents belonging to organisations that are *not* dominated by a market form of governance to a higher degree referred to multiple classes of value, such as direct and indirect use value, option and quasi option value, and existence value. Respondents belonging to organisations with a market-inclined form of governance primarily expressed direct use value. The main exceptions were respondent J, who only expressed bequest value, and respondent L, who did not express or mention any value at all – other than for other (non-municipal wastewater) types of synergies. This indicate that it existed different expectations on what a circular wastewater system would deliver, which could be a barrier for the process if not dealt with early in the planning phase.

4.2.1. Direct use value

Respondent mostly referred to the direct use of circulated water in various forms. Agricultural actors stated that they saw value in reused wastewater for irrigation and crops, and for utilising the nutrients in some way. Another direct use value was that a circular water system gives more freely usable water resources, as it decreases the dependency on groundwater. Circular water management was also considered to help with seasonal variations and water shortages in regional water

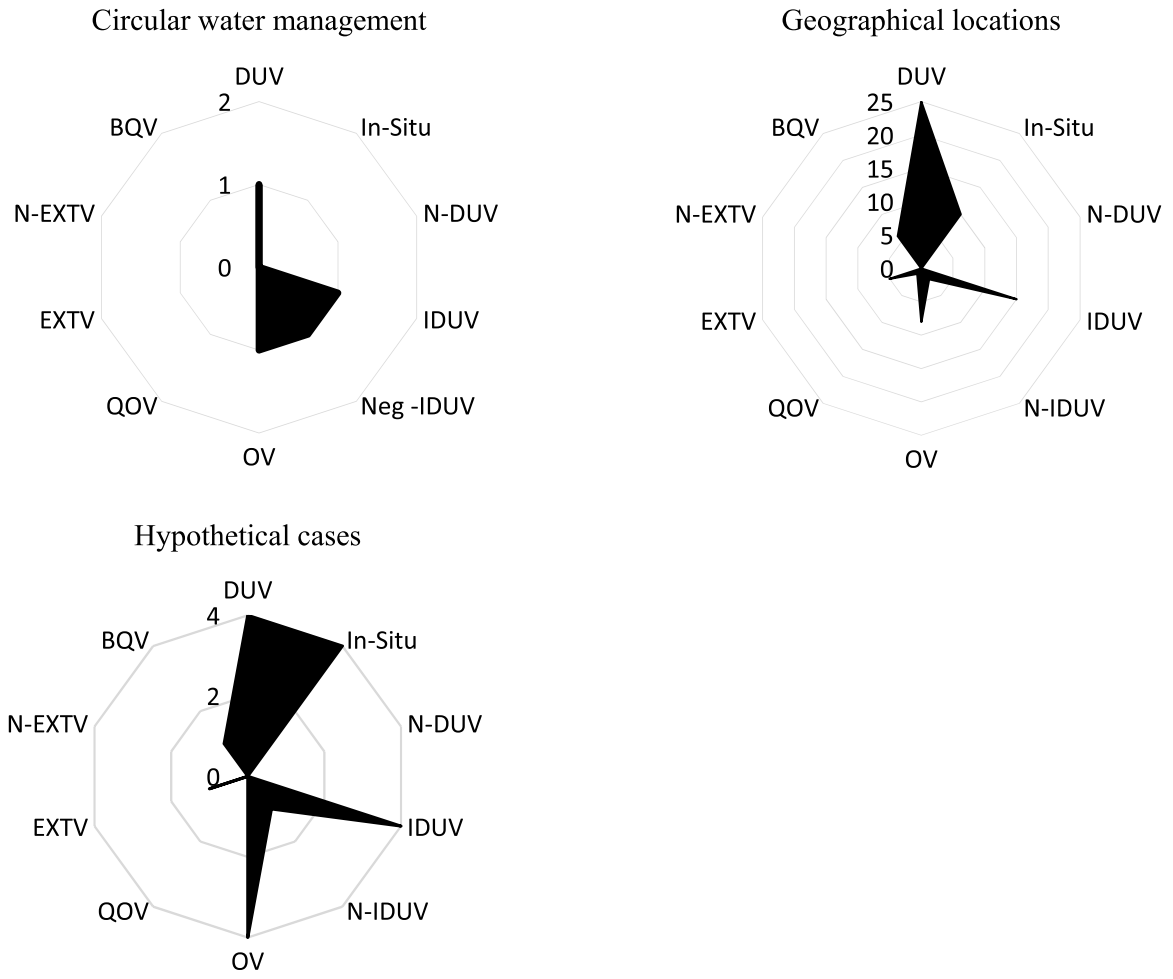

Fig. 7. Identified TEV classes from the perspective of the object of study. Scale indicates the number of articles containing content with regard to TEV classes as specified in coding frame (Table 1). In total, 34 articles were analysed in which geographical locations were studied in 30 articles, circular water management in two articles and hypothetical cases of water management in four articles. DUV = direct use value, N-DUV = negative direct use value, IDUV = indirect use value, N-IDUV = negative indirect use value, OV = option value, QOV = quasi option value, EXTV = existence value, N-EXTV = negative existence value, and BQV = bequest value.

reservoirs, where, for example, swimming pool owners can use recycled water when filling their pools in times of water scarcity.

The fishing industry saw a large potential for using recirculated wastewater in parts of production that do not directly come into contact with food products. However, in the future, if regulation regarding health factors and wastewater treatment becomes clearer, the industry saw a value for direct use even in processes that are in direct contact with food. At the time for the interviews, issues regarding municipal wastewater in food production were still rather sensitive.

Moreover, a negative direct use value was expressed in relation to not using water in a more circular way. This came from the fact that investments and constructions (e.g. in upgraded WWTPs) had already been made and thus represented a sunk cost. According to some of the respondents, not using the facility to the full extent would therefore be squandering an opportunity. Another negative direct use was expressed by a company that has put great efforts into marketing itself as self-sufficient – including in terms of water. Using "externally" recycled water could jeopardise this image, and potentially impact the business negatively.

4.2.2. *Indirect use value*

The second most common value class in the interviews was indirect use value. The majority of the indirect use values identified were related to trade and industry development in the municipality, innovation, employment and job creation. Respondents explicitly mentioned marine and agricultural innovation, business development, energy synergies such as biogas generation from biproducts and sewage sludge, and developing a meeting place for industry and academia. Other types of indirect value identified were related to the creation of wetlands for improving bird habitats and wetland crops. The identified indirect values in the material had a more environmental and social character compared to the direct use values. Nearly all respondents mentioned some form of indirect value relating to effects in connection with the surrounding environment.

4.2.3. *Option value*

When examining the identified option values in our material, some of the discussions referred to the uncertainty of future access to water and the capacity for the region to sustain the variety of urban, industrial and agricultural activities. Values were referred to in relation to the global sustainable development goals (SDG agenda 2030), especially to goals 6 and 14. Specific mentioned option values concerned long term care for scarce water resources in a changing environment. The concerns were not expressed by all of the respondents in the same way. Respondents from the municipal administration and the water treatment organisation, along with respondents from agriculture and fruit growers, expressed the greatest concerns, while most of the market producing respondents did not consider this a major problem. From a general perspective, the expressed and identified option values in the material indicated a clear link to the resilience and stability of the region.

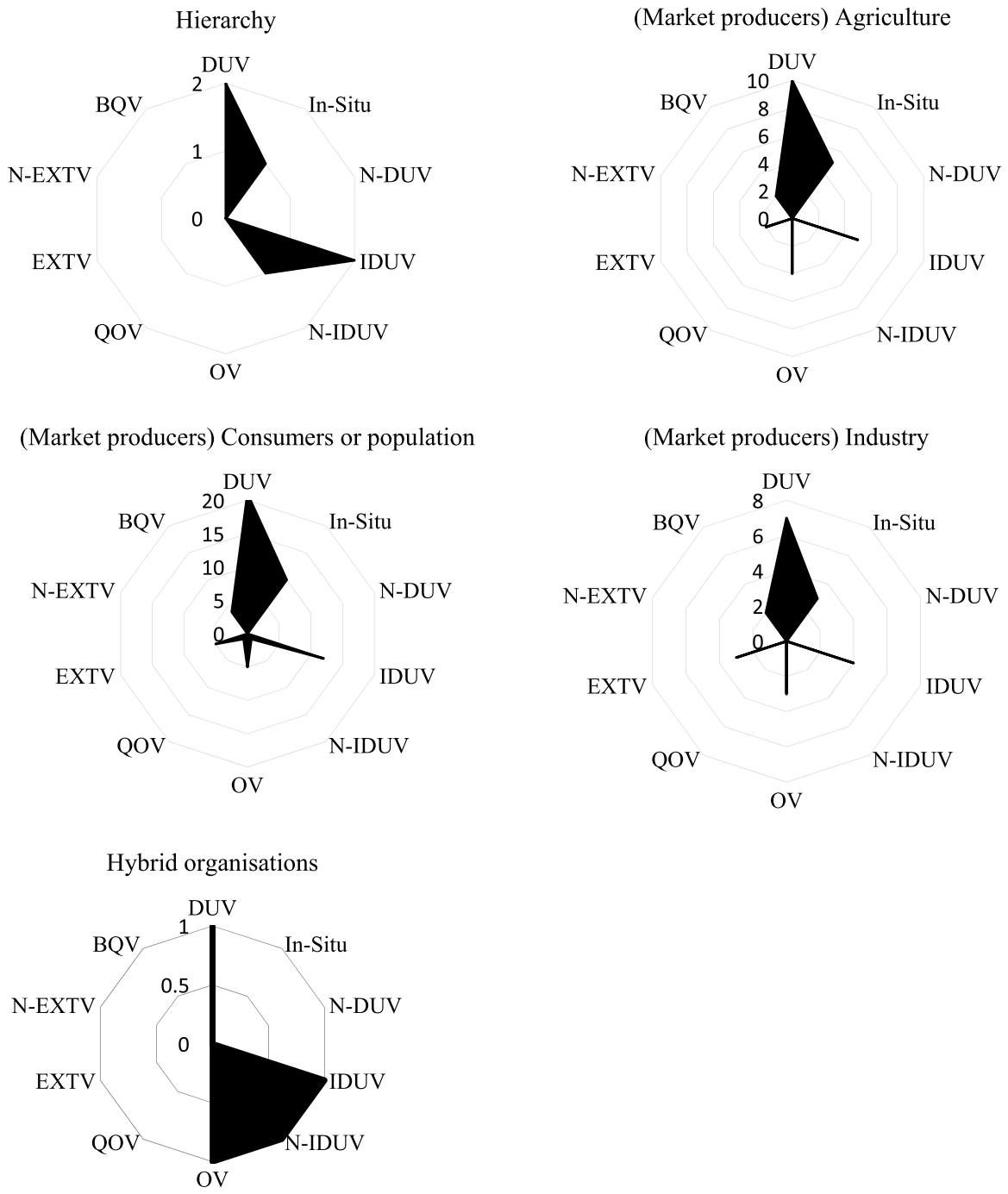

Fig. 8. Identified TEV classes from the perspective of organisations. Scale indicates the number of articles containing content with regard to TEV classes as specified in coding frame (Table 1). DUV = direct use value, N-DUV = negative direct use value, IDUV = indirect use value, N-IDUV = negative indirect use value, OV = option value, QOV = quasi option value, EXTV = existence value, N-EXTV = negative existence value, and BQV = bequest value.

4.2.4. *Quasi option value*

The quasi-option value found in the material was linked to the construction of the state-of-the-art water treatment facility with the capacity to purify water from a broad range of toxic substances and medical residues. The main reason for building the WWTP was to increase the knowledge around water treatment and a more circular water system. Another option value was linked to allowing scientists access to the WWTP, and thereby providing a test bed for research on water treatment processes. One example was research on removing pharmaceutical residues from the wastewater. In this sense, the circular operation of the WWTP could help advance knowledge and simultaneously minimise public financial costs. Moreover, Simrishamn is of the municipalities leading the work on sustainable marine environments in the Baltic Sea. To this purpose, it has established a centre for knowledge working towards healthy seas, a sustainable marine business environment, and a strengthened development of coastal settlements.

4.2.5. *Existence value*

Existence value was only brought up on two occasions in the material. Interestingly, both instances were in relation to farmers and the inherent value of soil for their practices. Respondents explained that farmers love their soil, care for it and feel proud of it. This, in turn, impacts their opinions, interests and behaviours as linked to potential outcomes of industrial symbiosis collaborations, for example.

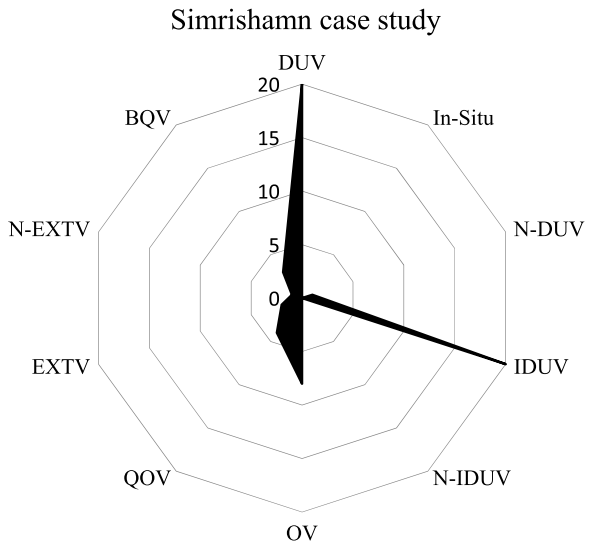

Fig. 9. Identified TEV classes from the Simrishamn case study. Scale indicates the number of interviews or documents containing content with regard to TEV classes as specified in coding frame (Table 1). DUV = direct use value, N-DUV = negative direct use value, IDUV = indirect use value, N-IDUV = negative indirect use value, OV = option value, QOV = quasi option value, EXTV = existence value, N-EXTV = negative existence value, and BQV = bequest value.

The analysis also identified negative existence values in the material. The negative existence value stemmed from the knowledge that some of the re-circulated water had been used in animal and meat processing. For some individuals, this was a very disturbing thought. From a purely analytical perspective, this was an excellent example of an existence value. Merely the knowledge that some of the water had been used in animal and meat production induced a negative value, even though there were no actual residues from the food industry left in the water.

4.2.6. Bequest value

A few occurrences of bequest values were also found, where respondents aspired to pass on or preserve environmental assets for future generations. Such values were brought up in relation to the modernisation of the municipal WWTPs. As mentioned, there was a specific ambition to "open up" the new technology for researchers to conduct experiments and share the results. In relation to bequest value, this entails leaving knowledge and the means for gaining new knowledge for future generations. Specific references were also made to environmental laws expressing that future generations should be ensured a healthy environment. This went hand in hand with the municipal political decision that laid the foundation for these structural wastewater investments, which claimed to promote sustainable development and a healthy, good environment for current and future generations.

5. Discussion

Circular wastewater collaborations involved multiple and complex relationships amongst various actors, and according to earlier studies there is a risk that conflicting preferences and value perceptions will undermine their effectiveness (Ramsheva et al., 2019). However, few studies have assessed the extent to which organisational values compete or align at the moment of entering a IWRM scheme. This study contributes to this gap by critically examining how TEV is applied in the literature and then exploring which values are expressed by different organisations taking part in an emerging circular wastewater system. The novelty in this research is the detailed information about value perceptions in circular wastewater collaborations gained by combining QCA, literature review and case study. The analysis shows how both research focus and organisation perspectives matter in terms of how value is perceived, which might influence the development of IWRM and circular wastewater operations. The QCA approach in combination with TEV also broadens the perception of value, as it goes beyond market-based valuations, and it widens the understanding of positive and negative TEV in water management.

The results showed that different stakeholders (organisations, actors and respondents) expressed different values regarding circular wastewater management. As indicated in Fig. 10 all value classes were mentioned amongst the respondents, although to varying degrees. The results also indicated, both in the literature review and in the case study, that there were converging values amongst the sectors and actors. Indeed, direct use value and indirect use value were defined as the

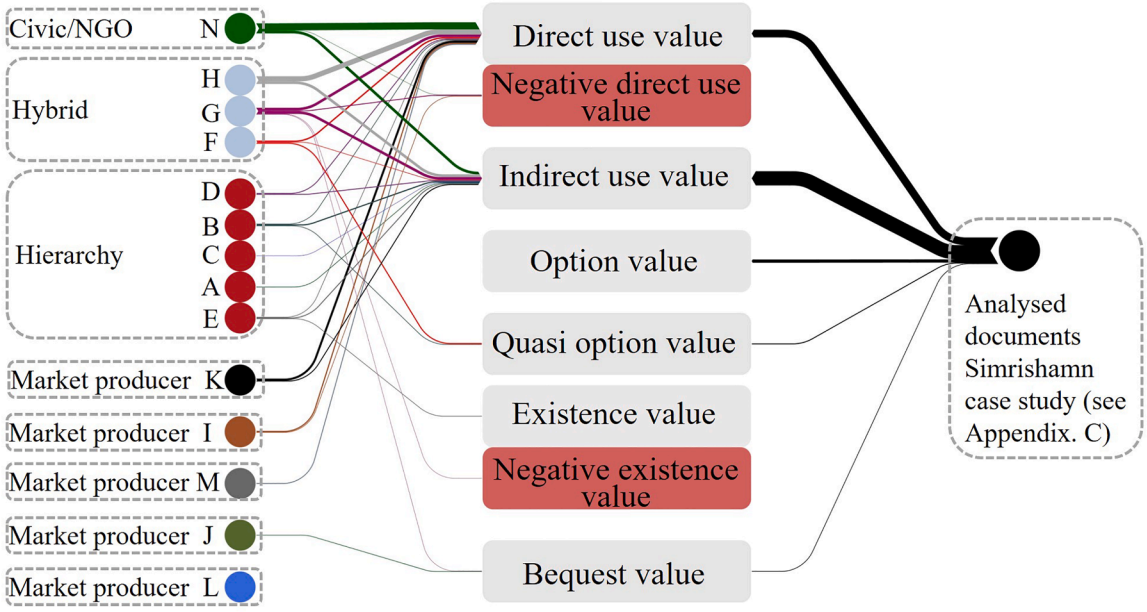

Fig. 10. This figure presents the results of the analysis and is ordered by the occurrence of TEV in the interviews. The coloured circles and boxes on the left indicate organisational groupings, letters indicate the respondent, and the thickness of the lines indicates the occurrence frequency of the specific value class for each respondent.

largest categories across all respondents and organisations. This suggests that circular wastewater management is seen as something concrete; a solution that can bring tangible outcomes to the direct users as well as to the geographical location as a whole. On the other hand, even if the existence and bequest value were discussed less often, such categories – signifying more inherent or intergenerational aspects – could also be associated with wastewater synergies.

The findings point towards a pattern of which values were expressed, included or excluded in the circular wastewater system. For example, values expressed in the review or by respondents and written documents were more or less aligned when it came to TEV classes. None the less, there might be conflicting values within a specific value class, as indicated by the negative and positive existence values. This indicates a potential risk of actors developing an internal value conflict as the circular water management scheme evolves. It is therefore important to discuss different values early on in the process of creating collaborations around circular water resources, where different values and goals become visible. Earlier research has shown the importance to visualise and verbalise values to achieve successful collaboration amongst divergent actors (Lazoroska and Palm, 2019).

As shown in the review, different value perceptions can be limited in scope. The municipal organisation and the water and sewage organisation expressed a broad spectrum of value classes compared to the other organisations. Even if both the narrow and broad value classes were mainly aligned, the different value focused (e.g. direct use value vs option value) can potentially lead to tensions between the involved actors (Bakker, 2002), where the economic perspectives can impact the wastewater management (Gandy, 2008). On the other hand when managed correctly, which in this case means identifying stakeholder preferences and values and then balancing the incentives accordingly, value perspectives can limit the tension between public and private management (Brown et al., 2017), including ownership and control of water resources.

Thus, carrying out this kind of value mapping exercise prior to formally engaging in a wastewater symbiosis could help actors avoid such collaborative challenges. Indeed, uncovering their different aspirations in a first step is important to allow actors, in a second step, to collectively align around goals and ambitions for joint commitments.

A limitation with this study is that it is a single case study. A single case study can give a deep understanding of one case, but it is not possible to draw general conclusions valid for all cases. This has partly been alleviated in this paper by presenting the case study results within the context of the literature review. The literature review is by no means exhaustive in terms of being all encompassing with regard to the plethora of value perspectives, but it focusses on TEV and organisation form. Still, this is a limitation of the study. The scope and depth of the analysis in this paper warrant specificity when it comes to material selection. With the well-defined search and selection process used here, the coding frame makes it possible to explore identified values and contribute with analytical generalisations.

In future studies, it would be interesting to make a comparative study between value categories expressed in an emerging versus a well-established circular water operation to investigate developments over time. This could also give insights into how conflicting values, both within and across organisations, may have been handled. Another idea is to dive deeper into different organisational attributes of actors taking part in circular water management operations. In doing so, researchers could create a better understanding of how organisational governance factors interact with or impact each other and the outcomes of resource synergies. It would also be valuable to expand the study of values in other resource efficient systems by focusing on other resource flows – perhaps placing energy exchanges at the centre instead of wastewater, which was the focus of this paper.

6. Conclusion

The literature review revealed that TEV in relation to circular water management is previously unexplored. In terms of value classes, earlier studies have identified and expressed a rather narrow value scope, since mainly positive direct and indirect value classes were identified.

From a market orientated organisational perspective, the majority of the identified values are direct use values, followed by indirect use values, existence, and option values. When it comes to hierarchical and hybrid organisations, values also include negative indirect values.

Results from the emerging circular wastewater collaboration in Simrishamn showed that all classes of value were expressed, although to varying degrees. Respondents mainly referred to direct and indirect use values when discussing wastewater synergies or symbiosis.

Looking at organisational belonging, the material indicates that respondents belonging to organisations that are *not* dominated by a market form of governance to a higher degree referred to multiple classes of value, ranging from direct and indirect use value to option and quasi option value, and existence value. Respondents belonging to organisations with a market-inclined form of governance, however, primarily expressed direct use value.

This study finds that there is a certain level of value coherence amongst organisations involved developing circular wastewater management. This can help minimize conflicts around decision-making and build consensus around how resources should be shared and how to organise a symbiosis. This also accentuates the understanding of what values that are the most effective when it comes to sustainable decision-making.

Ultimately, this study shows the importance of a detailed understanding of value perspectives, and the impact it can have on circular wastewater management. Overall, the analysis through this framework allows for a more robust and accurate assessment of the impacts of various activities or policies. It provides decision-makers with a more complete picture of the costs and benefits involved, thereby enabling them to make more informed choices that better align with societal goals and values. It also provides important clues as to why some of these solutions are successfully implemented while others are not. Thus, strategic planning and effective stakeholder engagement guided by value perspectives can enhance the legitimacy and facilitate the policy development of circular solutions.

Credit author statement

Wadström. C: Conceptualization, Investigation, Methodology, Validation, Formal analysis, Literature review, Writing original draft, Review and editing, Visualization. **Södergren. K:** Conceptualization, Investigation, Methodology, Validation, Formal analysis, Writing original draft, Review and editing. **Palm. J:** Writing original draft, Validation, Supervision, Review and editing, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Supplementary materials

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