SCIENCE & PRACTICE: THE CASE STUDY OF CORAL REEF CONSERVATION & SEWAGE POLLUTION IN CURAÇAO

Elise Leiser
Student number : 7036051
Email : e.leiser@students.uu.nl
Date : 01/07/2022
Master : Sustainable Development
Track : Earth System Governance

Faculty of Geosciences, Utrecht University
Course code : GEO4-2321 & GEO4-2322
Credits : 45 ECTS
Supervisor : Frank Laerhoven
Second reader : Peter Driessen
Word count : 13725

Acknowledgements. I am grateful for the encouragement and the direction of Frank Laerhoven. I also wish to thank Danick Trouwloon, the second reader Peter Driessen, and friends who offered feedbacks on my work. I also wish to thank all the interviewees, without whom I would not have been able to conduct this research.

Key concepts. Research uptake, Curaçao, sewage, corals

Abstract. Much research is being conducted on environmental issues but more knowledge does not necessarily lead to more decisions that take into account such knowledge. A low research uptake can therefore be a threat to ecosystems. An example is research going on about coral reefs and pollution in Curaçao. Coral reefs are vibrant ecosystems and provide many services. They support the economy and protect the coasts. However, they are declining as many hazards threaten them such as sewage that pours out into the sea. Scientific research is being conducted on that topic, but a major issue is the insufficient uptake of research by the policy sphere and the civil society to adopt environmental friendly decisions and behaviours. This master thesis is embedded in the SEALINK project, which aims at understanding how pollution such as sewage impacts the coral reef in Curaçao, and more precisely to its work package on research uptake strategies. This thesis first identifies in the literature the conditions under which research uptake is optimal. Literature highlights three criteria that knowledge should meet in order to have an optimal research uptake: legitimacy, credibility and salience. The salience of the scientific knowledge produced on sewage pollution and its impact on the reef is the focus of this thesis as the legitimacy and credibility of the knowledge produced on sewage are assumed to be met already. Salience refers to the relevance of the knowledge produced for the users of science, such as policy makers. A lack of salience can be the cause of differences in timerames, in the vocabulary used between the scientist and users of knowledge, for instance. The stakeholders that affect sewage in Curaçao, such as the ministry in charge of sewage management, companies that pick up sewage, the tourism industry, or fishermen, were then listed to be interviewed. Interviews of these stakeholders were conducted to explore the behaviours undermining salience of the knowledge produced on the topic at hand. The results show that this knowledge lacks salience because of an operational misfit between the demand for, and supply of knowledge. Recommendations to the local actors and to future researchers on solutions to create more salient knowledge and therefore to have optimal research uptake to protect the reef better, are proposed under the form of science-policy interfaces with an emphasis on knowledge co-production as the main approach to improve the science and practice relationship.

Table of content

Tables

Figures

Pictures

1. INTRODUCTION

1.1. THE PROBLEM WITH RESEARCH UPTAKE

Much research is being done on environmental issues, even more now as climate change, ecosystem pollution, are becoming more and more severe, and environmental problems are multiplying. Science plays a primary role in sustainable development and in ecosystem conservation. Scientists provide information to the public and to governments in the hope to influence people to make environmentally friendly decisions. Science is therefore linked to action as it participates in the framing of the issues and gives significant insights on possible solutions. However, the production of science doesn't necessarily lead to its uptake. Research uptake refers to 'the use of research evidence by researchers, policymakers, implementers or practitioners to inform policy or practice' (Malaria Consortium, 2016, p.3). Low research uptake can negatively impact ecosystems if decisions are made without considering the scientific knowledge provided on the matter.

An example of such a situation is the case of science being produced on coral reefs and the threats to them, notably on islands such as Curaçao. Despite the fact that information is provided on the reef state, it is still endangered, which questions the use of science in the decision-making process on that issue.

1.2. CASE STUDY : THE CORAL REEF & SEWAGE POLLUTION IN CURAÇAO

Coral reefs are vibrant ecosystems. The biodiversity they contain and all the ecosystem services they provide, such as fisheries, recreation with tourism, and regulating services by protecting the coastal areas (Woodhead et al., 2019) make them extremely valuable. The Dutch Caribbean Islands such as Curaçao, are known for their beautiful corals that attract thousands of tourists every year (DCNA, 2016). Curaçao is a Small Island Development State located in the Wider Caribbean Region and is an autonomous country within the Kingdom of the Netherlands. A

big part of Curaçao livelihoods is based on the reef. Figure 1 presents all the benefits derived from healthy coral reefs in Curaçao.

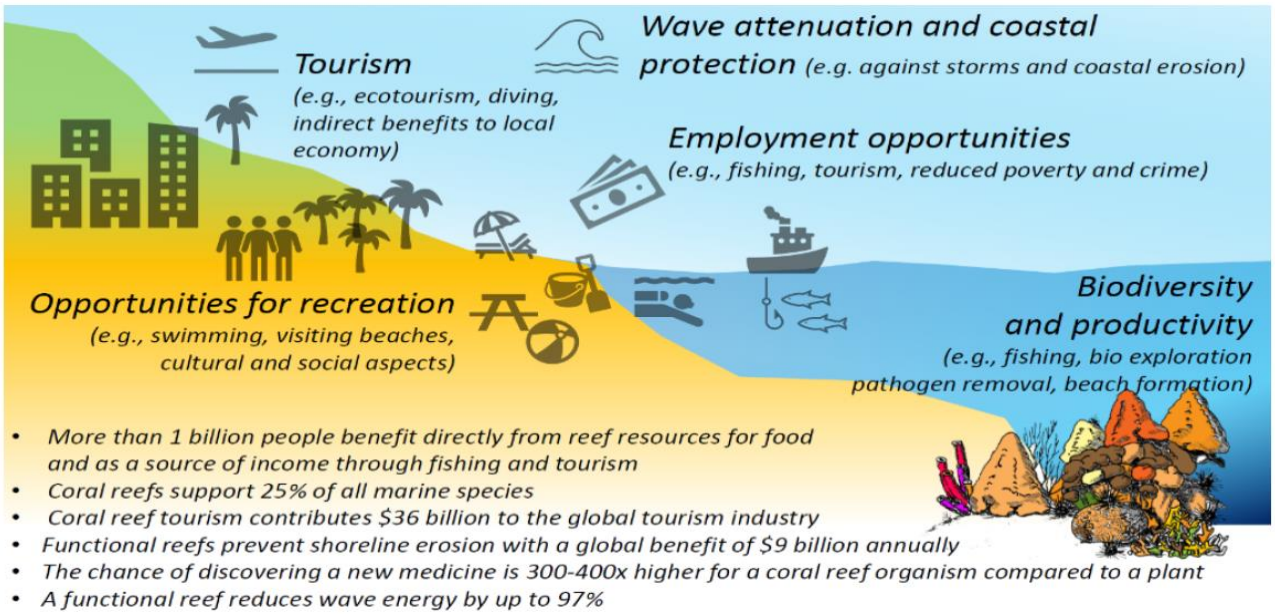


Figure 1: Physical, biological, economic, and cultural benefits derived from coral reefs. Taken from NIOZ, 2021.

Curaçao coral reefs are still healthy compared to other Caribbean islands. Still, there has been a decline of the living corals of 50% between 1982 and 2015 (Waitt Institute, 2017), so the reef remains endangered. The two pictures below show the difference between a healthy reef and a damaged one. In Curaçao, the reef is becoming as on the right side picture.

Picture 1: Healthy VS damaged reef. Taken from Vermeij, M., 2021.

Coral reefs are threatened by many hazards. One major threat to the reef in Curaçao is the pollution from sewage that comes as runoff into the sea. Sewage leakage into the sea harms corals in many ways. For instance, it affects coral species abundance and composition, notably because of the nutrients, toxic substances, and sediments it contains (Pastorok & Bilyard, 1985).

In Curaçao, the sewage system is composed of four wastewater treatment plants, but they don't function properly, leading to only 16% of the wastewater being treated. The other 84% is untreated and goes into the land and sea. Moreover, only 33% of the local population is connected to the central sewerage system (Adshead et al., 2018) as shown by Figure 2 below.

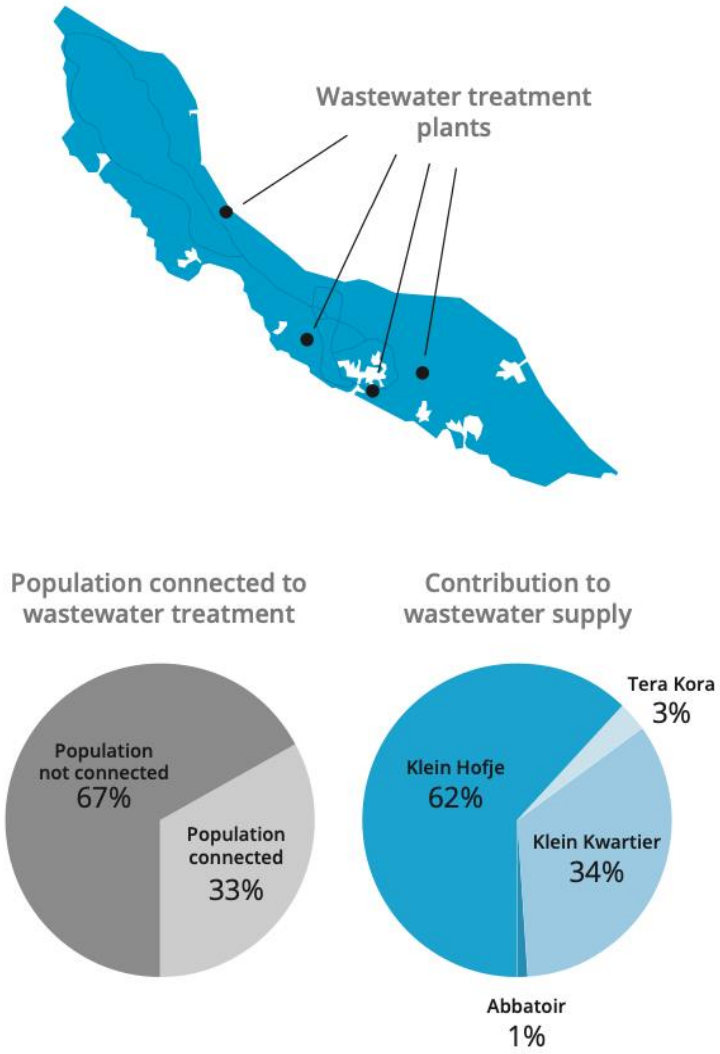
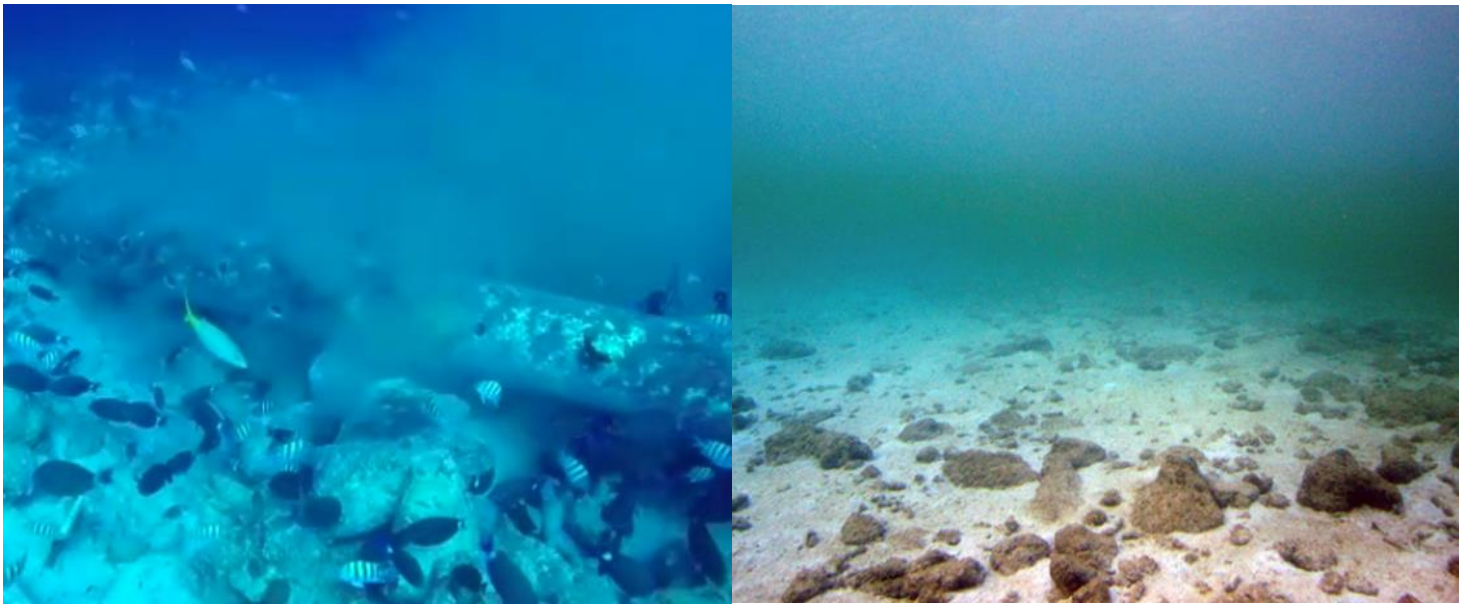


Figure 2. The four wastewater treatment plants in Curaçao, their contribution to wastewater supply and the system distribution. Taken from Adshead et al., 2018

Consequently, many buildings such as coastal hotels and houses that are not well connected to the sewage system, dump their sewage 'in poorly maintained septic tanks and cesspits', which leak into the ground and water (Vermeij, 2021). Leakages from cesspits are frequent, many residents see that they are less and less frequently emptied, but the lack of money to fix them remains an issue for locals. Besides the existence of old infrastructures, a major problem is the dumping of sewage directly into the sea as shown by Picture 2 below. Sometimes, cesspits are emptied by vacuum trucks which dump sewage directly into the sea because of the overcapacity of the treatment plants, or the absence of treatment mechanisms for certain types of wastewater such as industrial wastewater or medical wastewater, or also because of the lower cost of such action (Interviewee from the Public Work Department, Minister of Traffic, Transportation and Urban Planning, personal communication, February 25th, 2020).



Picture 2: Left : Sewage outfalls in Curaçao. Right : Groundwater outflow in Curaçao. The brown color is due to sewage water and organic material originating from land. Taken from Vermeij, M., 2021

1.3. THE SEALINK PROJECT

In order to deal with the reef decline, to understand the threats to it, and to investigate what makes it more likely that research is uptaken in this specific case study of Curaçao, a new project, the SEALINK project which aims at assessing 'How dispersion of substances on land and at sea affect coral reefs' (Vermeij, 2021) has been launched. This is an interdisciplinary

research project, conducted by different organisations such as the research center Carmabi in Curaçao, the Copernicus Institute of Sustainable Development of Utrecht University, the Water Management Department of the Technical University of Delft, and so on (Vermeij, 2021), which goal is to 'take a truly integrated look at how the distribution of human pollution (chemicals, sewage, etc) from land affects the Caribbean coral reefs' (NIOZ, 2021). SEALINK is composed of five different subprojects. Three of them are natural science projects that are looking at substances fluxes present in the water and at these substance's movement for instance. Another work package is looking at risk assessments models, and the last one is a social science subproject.

This master thesis is embedded in the latter work package that is looking at research uptake and more precisely at strategies to 'maximize the use of scientific findings in complex, environmental decision-making contexts' (Vermeij, 2021, Subproject section), which aims to ensure that all the scientific knowledge provided by the other subprojects is going to be used by knowledge users to make environmentally friendly decisions. Indeed, even if research is being conducted on the impact of land pollution such as sewage, on the marine environment, scientific research, although necessary, is not sufficient to protect the reef. One key problem is ensuring that policy-makers and the civil society use this scientific knowledge, to create effective policies and to adopt environmentally sound behaviours.

1.4. KNOWLEDGE GAP

The exploration of what contributes to research uptake have emerged from the debate about the nature and role of science. Experts regret that scientific knowledge is under-used by decision-makers; simultaneously, policymakers and the civil society emphasize a need for context-specific scientific knowledge (Runhaar et al., 2016; Cash et al., 2003). However, all these stakeholders do not necessarily have the same way of shaping and dealing with environmental issues, which can make the interactions between these actors difficult (Runhaar et al., 2016). The relationship between science and practice is not solid, even more regarding environmental matters where many diverse stakeholders have opposing needs and interests (Van Enst et al., 2014). Cash et al. (2003) emphasize that scientists and policy makers might consider different information to be relevant to them. It can also be hard for scientists to produce science well-suited for policy use, without compromising the information they are

providing, and their career. Moreover, dealing with issues such as environmental ones consist of dealing with matters that have several dimensions, political, social, economical, which hinders communication and coordination between actors (Cash et al., 2003).

The under-use of environmental science can be observed in many places. Scientists have warned decision-makers and the large public for decades about the declining state of ecosystems but overall, there are not enough actions yet to reverse the situation.

Thus, scientific knowledge is being produced but many elements can hinder, or help, its uptake. My interest here is the uptake of science produced on sewage pollution and its impact on the reef, in Curaçao. The knowledge gap is therefore that, what contributes to the uptake of research on the impact of sewage on the reef in Curaçao, is not known in sufficient detail.

1.5. RESEARCH OBJECTIVE AND RESEARCH QUESTIONS

Accordingly, the research objective is to get insights on what hinders, or helps, the research uptake to be optimal, in the case of knowledge being produced on the topic at hand, so that stakeholders can possibly adopt environmentally sound behaviours towards the reefs by protecting it from sewage runoff.

The main research question that arises from it is: What hinders and what helps the uptake of scientific knowledge about sustainable sewage management by relevant stakeholders in Curaçao?

This leads to the following sub-questions:

- SQ1: What are the factors that contribute to or prevent optimal research uptake according to the literature?

This question presents the criteria that scientific knowledge needs to meet in order to be uptaken. It is based on a literature review on the factors for an optimal research uptake. This sub-question is answered by the conceptual framework.

- SQ2: To what extent do the factors that contribute to or prevent optimal research uptake according to the literature, apply to the case of sewage management in Curaçao?

This exploratory and explanatory question first presents the relevant stakeholders for the research, namely the stakeholders that affect or that are affected by the sewage process on the island, with their function and role regarding sewage. They are classified in two categories, the knowledge producers and the knowledge users. This sub-question then presents the elements that help or hinder the uptake of science on sewage and its impact on the reef in Curaçao, explored during the semi-structured interviews of the relevant stakeholders.

- SQ3: How can the uptake of scientific knowledge regarding sustainable sewage management in Curaçao, be improved?

The answer to this question is based on a literature review on research uptake strategies and on the findings of SQ2. It provides insights on strategies to improve research uptake, under the form of recommendations presented in the discussion section.

1.6. Research Framework

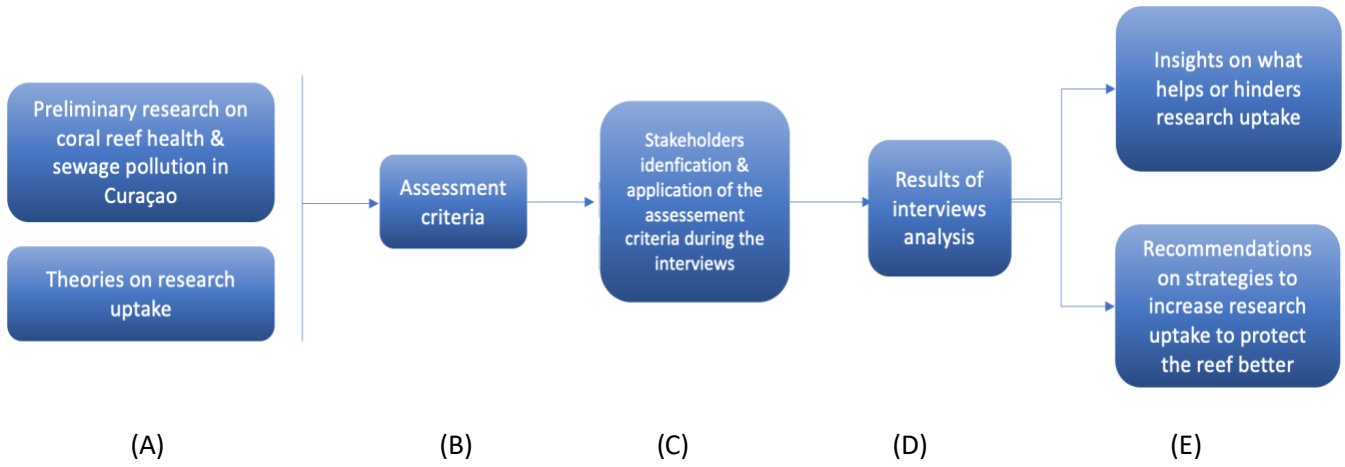


FIgure 3. Research Framework

(A) corresponds to a desk research. It consists of preliminary research on the sewage management and pollution on the island, and its impact on the coral reef, and of a literature review on research uptake theories, with a focus on what helps or hinders the use of science by knowledge users.

(B) consists of the choice of an analytical framework based on the precedent literature review, to base the interviews on. Assessment criteria are established from it.

(C) corresponds to the field work of the research. The relevant stakeholders are identified and contacted to plan interviews. The interviews' aims at revealing what helps or hinders research uptake on sewage pollution and its impact on the reef in Curaçao.

(D) represents the analytical phase of the research during which the interview's answers are analysed.

(E) corresponds to the recommendations phase to the relevant stakeholders, on strategies to increase the research uptake on the topic at hand. It also brings insights on research uptake theories and on the assessment criteria used for the research.

1.7. SCIENTIFIC AND SOCIAL RELEVANCE

This project feeds research on what contributes to the use of scientific knowledge in the decision-making process in the context of this case study, which is crucial in an era of climate change where scientists and experts play a major role in providing knowledge on diverse topics, in the hope to influence policies and people's behaviours. The interviews might lead to new elements to be taken into account, or to invalid some, when looking at what contributes to research uptake, at least in the context of this thesis case study.

In parallel, it also ensures that the information produced by the SEALINK project research is not in vain and is actually considered by users to improve the sewage pollution situation and protect the reef better. Indeed, this project provides information on research uptake to researchers working on the fifth subproject of SEALINK, so they can afterwards work on strategies to maximize the use of the science provided by the project. In this way, the findings contribute to the good and perennial impact of SEALINK's output on sewage and on the reef management, on citizen behaviour and on policies in the Dutch Caribbean.

Simultaneously, this research is useful for the whole community of Curaçao by revealing what hinders, or helps, the use of the scientific information provided, with the objective to help knowledge producers and knowledge users to cooperate more, to be more cohesive, in the hope

that science will be further taken into consideration in the decisions. Recommendations are provided to all the stakeholders on how to do so. It therefore participates in the preservation of the reef of the island, and of all of the physical, biological, economic, and cultural services it supports.

2. CONCEPTUAL RESEARCH DESIGN

The conceptual framework of this research is based on research uptake theories and analytical frameworks, with a particular focus on what contributes to the use of science in decision-making processes. Theories on stakeholders identification are also looked at, in order to compile all the possible relevant stakeholders for this case study.

2.1. RESEARCH UPTAKE

In order to fill in the gap between science and practice, which notably prevent environmental friendly measures to be implemented, more and more behavioural and social studies are trying to find out what are the barriers and stimuli to the uptake of climate science, in decision-making processes.

As mentioned previously, research uptake refers to the application of scientific evidence by knowledge users such as decisions-makers, or civil society, to inform practice (Malaria Consortium, 2016).

However, the relationship between the producers and users of science is not very strong for several reasons. Indeed, knowledge production is usually being through a top-down approach, without involving users in the process. There isn't necessary an adequacy between what users needs to achieve and what science suggests. Policy makers for instance must achieve certain objectives such as the economic development, which can contradict with scientists' objectives.

Therefore, despite the fact that scientists consider the knowledge they provide beneficial for users, the latter can often disagree. They also often have a hard time understanding how to make use of the research findings. As a consequence, the efficacy of many environmental studies is lower than expected because of disparities knowledge users and producers.

2.1.1. THREE CRITERIA FOR OPTIMAL RESEARCH UPTAKE

For scientific information to be uptaken by users, it is necessary that the knowledge produced meets certain conditions (Van Voorn et al., 2016). According to the literature, there are three criteria that science needs to meet in order to be used in decision-making processes. Cash et al.

(2003) state that research uptake is likely to be optimal if scientific knowledge is perceived to be credible, salient, and legitimate by the relevant stakeholders. 'Credibility involves scientific adequacy of the technical evidence and arguments. Salience deals with the relevance of the assessment to the needs of decision makers. Legitimacy reflects the perception that the production of information and technology has been respectful of stakeholders' divergent values and beliefs, unbiased in its conduct, and fair in its treatment of opposing views and interests' (Cash et al., 2003, p.1).

2.1.2. PROBLEMS UNDERMINING RESEARCH UPTAKE

Van Enst et al. (2014) created a framework of the problems influencing research uptake, based on these three criteria. It categorizes these problems under three meta-problems, with their associated stakeholders' behaviours, and the adverse influence these behaviours have on the three criteria and consequently on research uptake. Table 1 below presents them.

Meta level problems	*Behaviour of scientists, policy-makers and stakeholders*	*Adverse influence on the effectiveness of scientific knowledge*	*Implications for decision-making processes*
Strategic use of knowledge by policy	Knowledge is contested by particular groups (e.g. Michaels, 2009; Sarawitz, 2004; Guston, 2001)	Legitimacy, credibility	Scientific information insufficiently forms the basis of policy-decisions
	Knowledge is deliberately ignored by policy-makers (e.g. Wardekker et al., 2008; Owens et al., 2006; Oreskes, 2004)	Salience, legitimacy, credibility	
	Knowledge is selectively used (e.g. Owens et al., 2006; Cortner, 2000)	Legitimacy, salience	
	The use of counter-expertise in order to disqualify contested knowledge ('report wars') (e.g. Van Buuren and Edelenbos, 2004; Fenger and Kok, 2001)	Legitimacy, credibility, salience	
Strategic production of knowledge by science	Scientist selectively presenting knowledge ('Issue Advocate') (e.g. Lackey, 2007; Pielke, 2004, 2007; McCool and Stankey, 2004)	Legitimacy, credibility	
	Scientist joining competing knowledge coalitions (e.g. Lackey, 2007; Van Buuren and Edelenbos, 2004)	Legitimacy, credibility	
	Scientist deliberately produce incomplete knowledge in terms of other stakeholders (e.g. Turnhout et al., 2007; Bäckstrand, 2003)	Legitimacy, credibility	
Operational misfit between demand for, and supply of knowledge	Scientists and policy-makers employ diffeent timeframes and levels of abstraction (e.g. Strydom et al., 2010; Van Buuren and Edelenbos, 2004; Wiltshire, 2001)	Salience	
	Scientists, policy-makers and other stakeholders encounter differences in discourses, goals and rewards (e.g. Strydom et al., 2010; Pohl, 2008; Wardekker et al., 2008; Elzinga and Jamison, 1995)	Salience	
	Policy-makers insufficiently develop clear research questions (e.g. Derksen, 2011; Holmes and Clark, 2008; Sarewitz and Pielke, 2007)	Salience	
	Policy-makers have insufficient access to knowledge (e.g. Sarawitz and Pielke, 2007; McNie, 2007; Ducroty and Elliott, 1997)	Salience	

Table 1: Problems influencing the interaction between science and policy. Taken from Van Enst et al., 2014

The term ‘behaviour’ chosen by Van Enst et al. (2014) is kept during the whole paper to be in accord with the framework, even if that terminology can sometimes seem inadequate for some of them that can resemble more ‘situations’ than behaviours.

When looking at these behaviours and considering the three criteria, I decided that my interest lies on the salience aspect of scientific knowledge, and consequently on the behaviours that undermine salience; therefore three of the four behaviours from the meta problem ‘Strategic use of knowledge by policy, and the four behaviours of the meta problem ‘Operational misfit between demand for, and supply of ksnowledge’. Indeed, I assumed that the knowledge being produced on the impact of sewage on coral reef health, in Curaçao, from previous researchers, but also from the researchers of the SEALINK project, is credible and legitimate. It is already known that sewage leakage into the sea harms corals in several ways. Much research is being conducted on that topic and they all come to the same conclusion regarding the negative effects of sewage on corals (Pastorok & Bilyard, 1985). Therefore, there is scientific knowledge being produced but the extent to which it is salient to the needs of users, is uncertain. This focus is based on strong assumptions and full responsibility is taken by the researcher. Moreover, the two meta-problems that affect salience, which are the strategic use of knowledge and the operational misfit between demand for, and supply of knowledge, refers to behaviours related to the use of scientific knowledge, and to the relationship between the producers and users of information, which correspond to the focus of this research.

It is true that the way knowledge is produced can affect its uptake, as presented by Van Enst et al. (2014) framework. Although this aspect is interesting, it is left out in this project. Further research could be conducted on these aspects. In conclusion, the focus is the behaviours that lead to a lack of salience of the knowledge produced on the topic at hand.

It is essential to notice that the behaviours from the meta problem ‘Strategic use of knowledge by policy’ that undermine salience, also affect the legitimacy and credibility of scientific knowledge. The possible impact of these behaviours on the credibility and legitimacy of the knowledge produced is discussed in the results and discussion sections.

Thus, salience ‘refers to the relevance of information for an actor’s decision choices, or for the choices that affect a given stakeholder’(Cash et al., 2003, p.4). Panisset et al. (2012) highlight that salient knowledge means that it is framed in a way that is relevant for the policy sphere, while ensuring legitimacy of scientists and of their work. One typical pitfall is indeed having

very interesting questions within science but with no impact and relevance on the practical world of politicians. This corresponds to a lack of salience of scientific knowledge. The biggest challenge is therefore to provide knowledge that meets the needs of decision makers so science can impact the practical world.

The meta-problems and behaviours that I am focusing on are presented in Table 2 below.

Meta-problem	**Types of Behaviours**	**Behaviours explanation**
Strategic use of knowledge by policy: It is related to oppositions and actors with conflicting interests or views, using either existing knowledge or their own knowledge and reports in a strategic way, defending their interests.	(1) Knowledge is deliberately ignored (affects salience, legitimacy, credibility)	'Many researchers have suggested that particular policies are pursued in spite of their efforts to convince policy-makers to do otherwise but also that knowledge can be controversial, or uncomfortable ahead of contemporary policy agendas.' (Van Enst et al., 2014, p.7). 'Knowledge is considered inconvenient because it is not in line with preference or policy decisions.' (Van Enst et al., 2014, p.7). 'Decision-makers (and civil society) do not consider the knowledge at hand relevant to the decision at stake' (Van Enst et al., 2014, p.7). Therefore, the knowledge produced is deliberately ignored by users for two main reasons: it is not relevant for their decisions to be made; and/or bothersome because the information provided goes against the decisions they want to make.
Decisions makers invoke science to speak when it is in concert with their preferred policy preferences and ignore it when it is not. (Van Enst et al., 2014, p.(5-6)	(2)Knowledge is selectively used (affects salience, legitimacy)	This behaviour might have different explanations such as 'e.g.politicians ask for advice only to legitimize their preformed decisions' (Van Enst et al., 2014, p.7). Therefore, knowledge users don't use the entire knowledge at their disposal. It can be for different reasons such as : the knowledge is used after the decisions are made in order to justify the soundness of the decisions, or some information provided is too complex, too abstract, not relevant for the decisions to be made, for instance.
	(3)The use of counter expertise in order to disqualify contested knowledge (affects salience, legitimacy, credibility)	'Counter-expertise and reports may be produced in order to delay discussions and decision-making processes, leading to little recognition of the importance of certain environmental issues, resulting in little political will and involvement of stakeholder'(Van Enst et al., 2014, p.7) 'For the production of this counter-expertise, two reasons can be identified. The first reason refers to situations where there is little agreement on the produced knowledge and where knowledge is misused or misunderstood' (Van Enst et al., 2014, p.7) Secondly, counter-expertise and reports may be produced in order to delay

		discussions and decision-making processes, leading to little recognition of the importance of certain (for example) environmental issues, resulting in little political will and involvement of stakeholders' (Van Enst et al., 2014, p.7).
Operational misfit between demand for, and supply of knowledge: This is often linked to the differences in culture, between the "world of science" and the "world of policy" (Van Enst et al., 2014, p.9)	(4)Differences in timeframes and in level of abstraction (affects salience)	'The timeframe of research and policy, the language and mutual images, and the notion of reality differ fundamentally, which could lead to problems regarding the interactions' between the relevant stakeholders.' (Van Enst et al., 2014, p.9) This includes: -the 'delivery of knowledge science might take longer to produce, than policy (and civil society) is willing to wait for.' (Van Enst et al., 2014, p.9). The political world & civil society, and the scientific world don't have the same timeframe as decision-makers are usually in office for a short period of time and usually focus on short term problems; while scientists usually do research over years. -'The knowledge produced might not be as understandable to policy-makers (and civil society) as it is to scientists, due to the difference in language and abstraction levels.' (Van Enst et al., 2014, p.9). 'The failure of scientists to relate to the decision-making context, and the policymakers often limited understanding of science, leads to limited understanding of each other's research demands and produced knowledge'(Van Enst et al., 2014, p.9).
	(5)Differences in discourses, goals, and rewards (affects salience)	'Scientists and policy-makers (and civil society) experience and understand the world differently'(Van Enst et al., 2014, p.10). There are differences depending on the world in which stakeholders belong. The information provided is not perceived and understood in the same way for all. Stakeholders can see and experience problems differently. Stakeholders have different : -discourses with refers to how topics are discussed, how is a problem perceived by the different stakeholders. -goals which refers to the achievement toward which effort is directed, so what is the objective of dealing with the situation at hand. -rewards which refers to something that is received for services done, so what is the recompense when dealing with the situation at hand.
	(6) The lack of clarity of the research questions of policy-makers (affects salience)	'The communication between what information is demanded and whether the information is already available or needs to be supplied, can be difficult to achieve for knowledge producers'(Van Enst et al., 2014, p.10). There is the 'difficulty of constructing proper research questions from a policy point of view.'(Van Enst et al., 2014, p.10).

		Therefore, policy makers have clear problems but don't necessarily know how to formulate scientific research questions which are relevant, or developed enough, for researchers. There are communication problems between the two worlds on the type of information which is asked for, and what is already available. Thus researchers might provide information that is not relevant for decision-makers.
	(7) Insufficient access to information (affects salience)	'Decisions could be affected if users are unable to access the knowledge they need for their decision-making process because they are not aware of the existence of this knowledge' (Van Enst et al., 2014, p.10); so users can't make informed decisions.

Table 2. Explanation of the behaviours that undermine salience. Taken from Van Enst et al., 2014

These behaviours are used as indicators for the research. Questions for the interviews are based on them, with the goal to explore which behaviours are present in this case study. Van Enst et al. (2014) framework has been chosen because it allows narrowing down the research to specific behaviours, which allows to create precise interview questions, so it is handy to use.

It is necessary to notice that the Van Enst et al. (2014) framework, even if it refers to science and policy interactions problems, has been applied to a broader range of stakeholders such as farmers, as presented in the case study of Ingram et al. (2016). It relates to decision-making processes and behavioural choices in general, so it can be applied to many types of stakeholders. In that way, it is relevant for this research. These behaviours were indeed explored among policymakers but also among the civil society, therefore the users of scientific knowledge at large.

2.2. STAKEHOLDERS' IDENTIFICATION

Stakeholders are understood as all the 'users (i.e. policy-makers) and other social actors who are relevant to and knowledgeable on the issue that is at stake' (Kunseler et al., 2015, p.2). To identify and categorise stakeholders, theories from Bryson (2004) and Reed et al. (2009), were used. The basic stakeholders analysis technique by Bryson (2004) and Reed et al. (2009) allows to identify stakeholders and their interests, to know their visions on specific issues, and the possible coalitions or opposition between them. Bryson technique encompasses brainstorming

all the potential stakeholders, by doing a desk research, looking at government websites, at online newspapers with articles that mention sewage on Curaçao, to identify possible stakeholders that are related in one way or another to the sewage process on Curaçao, for this case study; and then by specifying how each stakeholder might influence the problem at hand. Additionally, the snowball sampling method allows to reveal new stakeholders thanks to stakeholders identifying other stakeholders (Reed et al., 2009) notably during the interviews that were conducted. This process allows to identify the relevant stakeholders, to explain their role on sewage and to categorise them in two groups, according to their role on scientific knowledge: knowledge producers and knowledge users.

2.3. CONCEPTUAL FRAMEWORK

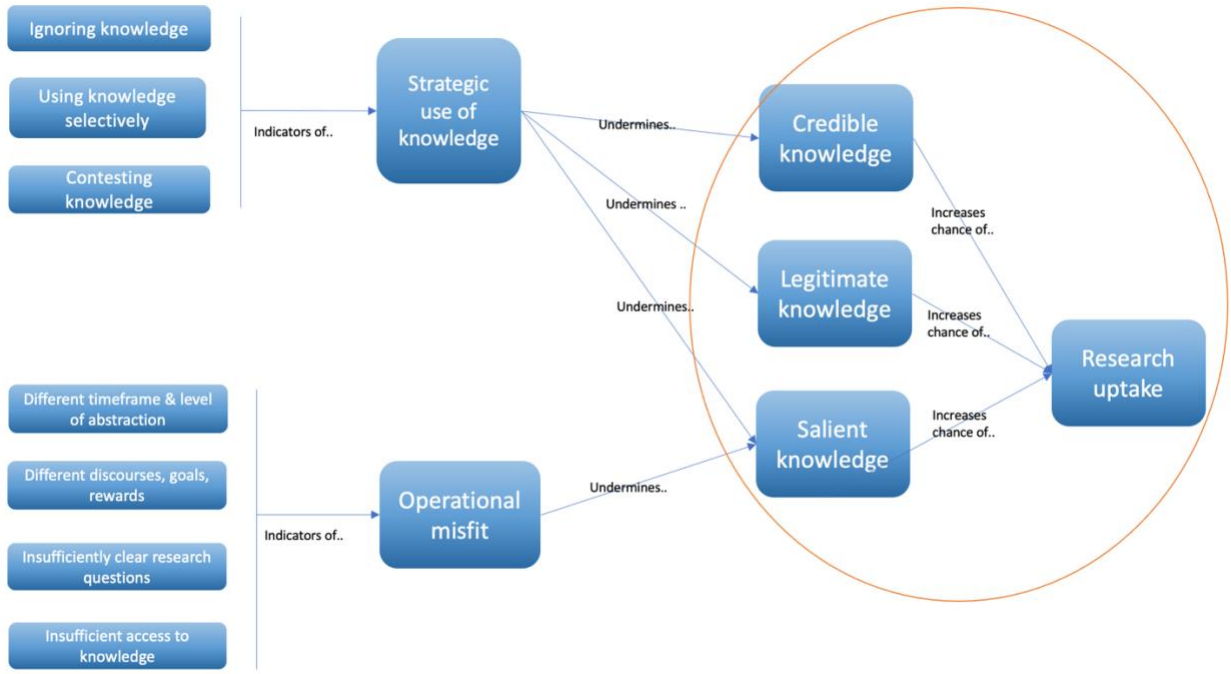


Figure 4 : Conceptual framework

This figure presents and summarizes the conceptual framework used in the research, based on the meta-problems and the associated behaviours that undermine the three criteria that science should meet to be used to have an optimal research uptake, and especially salience in this case study. The seven behaviours are understood as indicators of the two meta-problems.

3. METHOD

The research method encompasses desk research with literature reviews on the sewage management and on the reef of Curaçao, on research uptake theories, on stakeholders identification, on how to conduct semi-structured interviews, and on research uptake strategies; and field work in Curaçao to conduct the interviews.

3.1. SAMPLE SELECTION

The research process started by a desk research to learn more about the sewage management and pollution in Curaçao, and its impact on the reef, in order to get insights on the situation before going on the field. Local newspapers were used for that, such as the Curaçao Chronicle, the Antilliaans Dagblad and the Curaçao.nu. CARMABI and the SEALINK project websites were also researched to know more about the current state of the reef and the threats to it.

Then, research uptake theories and frameworks to base the analytical categories on for the interviews, were researched.The elements that came out the most, namely the three criteria, were selected to be the focus of the research, and to be used as the analytical framework. This literature review also answers SQ2.

To identify the relevant stakeholders, all the actors mentioned in the articles about sewage, in the local newspapers that were looked at during the first step of the desk research, were listed. The Curaçao government website was researched to understand who is in charge of the sewage management on the island. Google was also used with the keywords ‘sewage management Curaçao’ to see if more actors came up. Furthermore, the websites, the social network pages, and sometimes the Linkedin of the people, companies or organisations that were found in the first place, were explored to understand more in depth their role on sewage. The variable that was looked at is the role of each stakeholder in the sewage process. It can be polluting, cleaning, managing, regulating, raising awareness on the problem, and protesting, for instance. This desk research led to a compilation of the preliminary relevant stakeholders to be interviewed. A table was made with the organisation name, the contact person, the contact information, and the stakeholer’s role on sewage. Then, stakeholders were classified according to their relation to

the scientific knowledge on sewage, being either knowledge producer or user, but also more generally to related topics such as ocean conservation, environmental protection at large. The last question of each interview was asking who else could be a relevant person to talk to, regarding that topic. This led to a more complete list of stakeholders, using the snowball approach.

Lastly, a literature review on research uptake strategies was made after the results were analysed to see what solutions could be implemented in case of non optimal research uptake, which answers SQ3 at the same time.

3.2. OPERATIONALISATION OF VARIABLES

To reveal which behaviours were present in the case study, therefore to answer the second sub-question 'To what extent do the factors that contribute to or prevent optimal research uptake according to the literature, apply to the case of sewage management in Curacao?', two interview schemes were created, one for the knowledge users and one for the knowledge producers, as some questions were only relevant for one group of stakeholders. The questions were based on the analytical elements from the Van Enst et al. framework (2014), presented by Table 2, so on the seven behaviours, used as indicators, that are the focus of this research. Table 3 below presents what was asked to the interviewees in order to explore each behaviour. The exact questions lists can be found in the appendix.

Behaviours	**Operationalisation**
Knowledge is deliberately ignored.	To explore this behaviour, the respondents were asked about their usage of the knowledge on the topic at hand, if they take it into account in their decision making and why or why not? Is it because the information provided is not in line with policy preferences, so is irrelevant for the decisions to be made?
Knowledge is selectively used.	To explore this behaviour, the respondents were asked about their usage of the knowledge on the topic at hand. This behaviour echoes with the previous behaviour, as it deals with the way stakeholders use the knowledge available. More precisely, they were asked if, when they have reports on the topic, if they take into account all the information provided or only some parts of it ; and Why ? Is it because it is not understandable, not in line with their needs? They were also asked if they ever make decisions first and then use science to justify their actions.

The use of counter expertise in order to disqualify contested knowledge.	To explore this behaviour, the respondents were asked about their knowledge of any possible counter expertise being done by other stakeholders, on the topic at hand, in order to delay any upcoming decisions; or because the knowledge produced is contested.
Differences in timeframes & in level of abstraction regarding the sewage problem.	To explore this behaviour, respondents were asked about what is the time frame of the issue at hand, according to them; if the timeframe of science and policy on that issue match or not; how urgent is the situation for them; what degree of priority this issue has regarding other problems on the island. Users were also interrogated about the extent to which they know and understand the information provided by scientists on the topic at hand; if they find it too abstract, too far away from the practical world; if they understand knowledge producers clearly, as well as their reports? So what would need to be done differently? Knowledge producers were also asked if they encounter any communication problem with users; if they think that the science they do is understandable to everyone.
Differences in discourses, goals, and rewards.	To explore this behaviour, respondents were interrogated about what they know about the matter at hand, how they perceive the situation, why it is problematic or not according to them; why is it the way it is today? They were also asked about the goal they have by dealing with the situation, what is the objective behind solving that situation? Do they have other objectives that thwart this specific objective? How would solving the situation benefit them and the island? What is the reward if the situation is solved, what do they get?
The lack of clarity of the research questions.	Respondents were asked about the possible mismatch between the problems the political world & the civil society are facing regarding sewage notably, and the way it is translated in scientific questions; if there then is a mismatch between what scientists produce and what users need? Why?
Insufficient access to information.	To explore this behaviour, the respondents who were only the knowledge users here, were asked about their access to information on the topic at hand, if they are able to find information on the topic ; how ; easily or not.

Table 3. Operationalisation of the variables.

3.3. DATA COLLECTION & ANALYSIS

Once the preliminary stakeholders list was made, a first email approach was sent to each one of the stakeholders. Reminders by phone calls were made if no answers to the emails were received. Local residents were also interviewed, but in a more spontaneous way. For instance, some stakeholders that I interviewed invited some of their colleagues, who were not experts on the question, to join the interview.

The interviews were semi-conducted, so based on a question list, but allowing people to have more open conversations, so they could add any other relevant information that were not mentioned during the interviews preparation, and to be able to ask the respondents their independent thoughts on the topic and on certain aspects of it. It is then a mix of open and closed-ended questions, often followed by a how or why interrogation (Adams, 2015). Each interview lasted around half an hour. Different language register were used to frame the questions and the concepts when speaking to people, depending on the stakeholder's position, to make sure that the questions were understood. For instance, the way to talk to local residents was more simple and explanatory than when talking to officials from the government or other researchers, as they might not know or understand all the details about the situation. Also, there were some variations in the questions depending on the behaviours as some were destined to knowledge producers, and some to knowledge users only. Five weeks were allocated to the interviews. One interview per stakeholder was conducted. The interviews were conducted on site for most of them, and online when respondents were not in Curaçao. Notes were taken during the interviews to answer the questions list. It was chosen to not record the interviews to make interviewees feel more comfortable.

The interview's answers were then analysed. For each behaviours explored, several questions were asked; the answers to the questions corresponding to each behaviour were categorised with different colors to recognise easily which answers relate to which behaviour. Then, answers were compared within each category of stakeholders first, to see if there were differences in the answers of the respondents belonging to the same group. Then, the answers of the two categories of stakeholders were confronted. No software was used as there weren't too many interviews and the answers were not that long.

3.4. THE METHOD RELIABILITY & VALIDITY

The reliability and validity of the method are covered by learning from different sources of information such as literature reviews and interviews. Van Enst et al. (2014) framework is reliable and relevant as it is based on three well-known criteria, summarized by Cash et al. (2003), and as it deconstructs salience within different behaviours, which allow to have an analytical framework to use for the interviews. Moreover, questions were asked in a way to

explore all the different components of the behaviours. The interviews allow to answer the research question as many stakeholders as possible, from a lot of different organisations, for both categories of stakeholders, were interviewed. The analysis without any software is also reliable because not too many interviews were conducted and they all lasted around thirty minutes.

3.5. RESEARCH ETHICS

This research project is mainly based on a stakeholder analysis with interviews. Therefore, people were addressed directly, which required to pay a specific attention to the interviewees' consent, to not harming the participants in any way, and to let them answer according to their own criteria. For this, an informed consent form was distributed and filled in by all the stakeholders that participated in the research, before starting the data collection. Moreover, the respondents remain anonymous in this thesis, only their organisation is being mentioned. Also, all my data was stored safely in a file on my computer and I'm the only one that has access to it.

4. RESULTS

This chapter presents the results of the research, obtained by the exploration of the seven behaviours, in order to answer the main research question 'What hinders and what helps the uptake of scientific knowledge about sustainable sewage management by relevant stakeholders in Curacao?'.

The first sub-question 'What are the factors that contribute to or prevent optimal research uptake according to the literature?' is answered in the conceptual framework, by the literature review on the three criteria that scientific knowledge needs to meet to be uptaken, and on the behaviours of knowledge users and producers that undermine research uptake.

The second sub question 'To what extent do the factors that contribute to or prevent optimal research uptake according to the literature, apply to the case of sewage management in Curacao?' which is an exploratory and explanatory question, is answered below. It has two parts. First, in order to explore the seven behaviours, the relevant stakeholders to interview were compiled and separated into the two categories of knowledge producers and knowledge users. Then, each behaviour was analysed.

4.1. THE RELEVANT STAKEHOLDERS

A total of 26 people from 21 different organisations were interviewed, all being related to sewage in one way or another. In some organisations, several people with different positions were interviewed. Also, some people work for several organizations, or used to work for other organisations also interviewed, therefore, talking to one person was sometimes equivalent to talking to two different organisations. Moreover, some stakeholders are both knowledge users and producers in the sense that they are part of a tourism agency for example, but were also scientists such as marine biologists or chemists before, so they know a lot about the topic. However, the category producers or users for such stakeholders was chosen depending on their current affiliated organisation and not on the interviewee's knowledge background. Lastly, it happened several times during the fieldwork, that I was redirected to the same person for talking to different organisations, as some stakeholders were sometimes being knowledge

producers and users at the same time but in different organisations. Table 4 below presents all the interviewees and how they affect the sewage process.

Organisation/Company	**Description & Role on sewage management**
Ministry of Health, Environment and Nature (government)	The Ministry of Public Health, Environment & Nature is committed to the improvement of sanitation on the island. (https://gobiernu.cw/) Regarding sewage, it creates regulations about sewage management notably on its impact on the environment, but the lack of enforcement makes it hard to ensure that these regulations are respected.
Minister of Traffic, Transportation and Urban Planning with The Department of Public Works (government)	The Ministry of Traffic, Transport and Urban Planning of the Government of Curaçao is responsible for the urban development of the island. The Department of Public Works takes care of the building and upkeep of public infrastructures and facilities, of public and green spaces. It is the public construction and civil engineering body of Curacao. (https://gobiernu.cw/) This ministry, and more especially the department of Public Work, is the one responsible for the sewage treatment plants maintenance and development.
Selikor (private sector)	Selikor gives businesses recycling solutions that reduce business costs and that are environmentally friendly. (https://www.selikor.com/) Sewage is not their main focus but they have vacuum trucks that can remove all kinds of liquid waste from containers such as septic tanks. Sewage that can be recycled is transported to the wastewater recycling facility "Klein Hofje", which is one of the treatment plants on the island.
Curaçao Medical Center (state-run hospital)	CMC is the public hospital of Curaçao. (https://www.cmc.cw/) They have been disconnected to the sewage treatment because the type of wastewater they were producing couldn't be fully treated by the treatment plants; however, they are being reconnected after some work.
Biorock (private sector)	BIOROCK is a company that offers a range of compact and non-electric residential, domestic wastewater treatment plants. (https://biorock.com/) In Curaçao, their client was the Papagayo Resort.
Curacao Hospitality & Tourism Association CHATA	CHATA is a non-profit association. It represents 250 private organisations from the Tourism & Hospitality industry in Curaçao. (https://chata.org/)

(public & private)	The tourism sector could influence the way sewage is managed on the island, by putting more pressure on the government for instance. Indeed, in the long term, sewage can become a threat to tourism if the quality of the water is diminished, and if smelly dirty dumping spots, visible to people, multiply.
Curinde (semi-governmental)	Curinde offers professional support and facilities to parties interested in operating in the Curaçao Harbor Free Economic Zone, or the Curaçao Airport Free Economic Zone or the Industrial Park Brievengat. (https://www.curinde.com/) Curinde has to deal with all the sewage produced by the Industrial Park for instance.
Curaçao Tourism Board (public sector)	CTB is the key driver for the development of tourism on the island. It gathers public and private organisations to coordinate management, planning, and promotion efforts. Their goal is to make Curaçao a leisure and business destination. (https://www.curacaotouristboard.com/) The tourism sector could influence the way sewage is managed on the island, by putting more pressure on the government for instance. Indeed, in the long term, sewage can become a threat to tourism if the quality of the water is diminished, and if smelly dirty dumping spots, visible to us, multiply.
Porto mari restaurant (Private sector/civil society)	Porto Mari is a restaurant in the West of Curaçao that tries to recycle as much waste as possible, and that has a private sewage system as they are far from the island sewage system. They created a closed system underground that treats the water, and redistributes it to irrigate their fruit trees.
Residents / Fishermen (civil society)	They are residents picked up randomly. They don't know much about the sewage situation. Not all of them are connected to the sewage system, and have a private cesspit at home, which they don't really take care of.
Committee for Integrated and Sustainable Water Management	It is a governmental committee and acts as a working group. Its role is to make policy plans and to give advice to the government about water. It is composed of representatives from the government and experts. They work on water in general, including wastewater or sewage.
Maritime Authority of Curaçao	It is a governmental authority. Its goal is to ensure safe ships and clean seas. (https://maritimecuracao.org/)

	They supervise sewage treatment and disposal on-board of the vessels, in the waters, and in the harbours.
WAITT Institute	The Waitt Institute is a research institute which aims at creating and implementing sustainable ocean strategies, in partnership with governments and locals, by leading a team of international experts. (https://www.waittinstitute.org/) Sewage is not their main topic but they did research on the topic and they worked a lot with the local government.
Carmabi	The Caribbean Research and Management of Biodiversity is a non-profit organisation in Curaçao. Carmabi was established as a marine research institute but now has four pillars: Marine and Terrestrial Research, Park Management, Nature and Environment Education and Consultancy. (https://www.carmabi.org/) Carmabi started the SEALINK project in September 2021.
Pollution sub-programme of UNEP's Caribbean Environment Programme	The UNEP is the international authority that creates a global environmental agenda, promotes the implementation of the environmental dimension of sustainable development at a global scale, and serves as an authoritative advocate for the global environment. (https://www.unep.org/cep/) In this specific UNEP programme, they organised conferences, workshops, notably on sewage pollution.
Unique Curacao Foundation	It is an NGO which aims at managing and protecting natural areas. It organises activities such as clean ups, mangrove and tree planting. Education of the people and in schools is a big part of their work. . (https://www.uniekcuracao.com/) They don't focus on sewage directly, but on the threats to the environment, sewage included.
Ecovision	Ecovision is an environment and nature consultancy organisation. Their mission is to help clients to make environmentally sound decisions, through analytical research and open dialogue with stakeholders. (https://ecovisionnv.com/) When they receive a project in the sewage sector, their role is to investigate impact and mitigation.
Amigu di tera	It is an NGO which works on raising people's environmental awareness. (https://www.foei.org/member-groups/curacao/)

	They act quite a lot on sewage problems, such as on a mangrove city park in Curaçao, where they pushed the project to happen. They also do some lobbying to the government to prevent the construction of certain buildings to protect the local ecosystem.
Sea aquarium	It is a center dedicated to the protection and health of Curaçao's marine ecosystem. (https://curacao-sea-aquarium.com/) They don't focus on sewage directly but study the marine ecosystem and the threats to it.
Curacao Business Council for Sustainable Development (BPM)	It is a non-profit association for businesses, whose goal is to exchange knowledge and experience in several areas, such as the environnement, safety management, and to promote sustainable development. (http://www.bpmcuracao.com/) They sometimes deal with sewage management with some of their clients.
Dive shops / Curious2Dive	Dive shops such as Curious2Dive are owned by marine biologists who study and preserve the reef, who organise clean up sessions, raise awareness and so on. (https://www.curious2dive.com/)

Table 4: List of the interviewees

Legend:
Knowledge users
Knowledge producers

Knowledge users are composed of people from the ministries, from companies related to sewage management, from the tourism industry, and of local residents. The knowledge producers are composed of a range of experts on the topic at hand but also on environmental conservation and management at large, such as diver shops, environmental NGOs, marine biologists, and environmental consultants, that have knowledge on the sewage situation.

Now that all the stakeholders have been identified and presented, the analysis of the behaviours can be made. The two meta-problems and the associated behaviours are analysed below.

4.2. THE STRATEGIC USE OF KNOWLEDGE

This meta-problem is composed of three behaviours : the knowledge is deliberately ignored; the knowledge is selectively used; there is a use of counter expertise in order to disqualify contested knowledge.

4.2.1 KNOWLEDGE IS DELIBERATELY IGNORED

Amiguditerra stated that *'the government has a development mindset of engineers, project developers, instead of a sustainable development mindset'.* If the environmental science produced doesn't align with what decision-makers have planned, it can be deliberately ignored. The respondent illustrated his remarks by giving an example of a government project to build a road going through a national park, which was criticized by several organizations. An alternative was provided to officials, but the government refused to change its plan as it was not in line with their objective which was facilitating tourists' transportation. This example relates to environmental science in general, and not to sewage especially, but the interviewee highlighted that it is the same for every environmental issue on the island, sewage included. If the science produced doesn't align with what decision-makers have planned, it can be deliberately ignored.

The interviewee from the Waitt institute highlighted the same idea of Amiguditerra and added that, regarding sewage, even when investors were found and possibilities were presented to invest in sewage infrastructures notably, the gouvernement did not plan any further actions, even in full knowledge of the facts.

Knowledge users, on the other hand, tend to say that the knowledge produced is not deliberately ignored. Policy-makers all stated to be aware of the environmental science produced, but they underlined the fact that they also need to develop the island, and conduct projects in that sense, which do not necessarily align with scientists objectives.

Therefore, decision-makers seem to be aware of environmental science in general and regarding sustainable sewage management as well, but they choose to ignore it, because other priorities have them selecting for policies that run counter to what sustainable development should have them doing, instead. Indeed, policy makers are focusing on other matters such as developing tourism, strengthening the economy, improving the health system for instance.

It can then be concluded that some evidence was found regarding the deliberate ignorance of knowledge produced on environmental matters in general, but little evidence when it comes to knowledge on sewage specifically. I therefore conclude that this type of behaviour doesn't really seem to occur to an extent that it can be expected to undermine the credibility, legitimacy or salience of knowledge produced on sustainable sewage management, and consequently to subsequently jeopardize the uptake of this knowledge.

4.2.2. KNOWLEDGE IS SELECTIVELY USED

This behaviour echoes with the previous behaviour, as it deals with the way stakeholders use the knowledge available to them.

No evidence of the fact that 'politicians ask for advice only to legitimize their preformed decisions' was found, as the explanation of the behaviour shows. However, one respondent from the ministry of Traffic, Transportation and Urban Planning mentioned the fact that reports from the consultancy company Ecovision for instance, is the type of knowledge they tend to use because it relates to information they can applied in the practical world of policy, in contrary with the information provided by scientific reports that can appear too abstract and that doesn't provide practical solutions to the problems for exemple. Some respondents mentioned the fact knowledge on sustainability in general can be selectively used, however, the findings do not really concern information on sustainable sewage management.

I therefore conclude that this type of behaviour doesn't really seem to occur to an extent that it can be expected to undermine the legitimacy or salience of knowledge produced on sustainable sewage management, and consequently to subsequently jeopardize the uptake of this knowledge, as there is only little evidence of it.

4.2.3. THE USE OF COUNTER EXPERTISE IN ORDER TO DISQUALIFY CONTESTED KNOWLEDGE

No evidence of this behaviour was found. I therefore conclude that this type of behaviour doesn't occur to an extent that it can be expected to undermine the credibility, legitimacy or salience of knowledge produced on sustainable sewage management, and consequently to subsequently jeopardize the uptake of this knowledge, as there is no evidence of it.

4.2.4. CONCLUSION

Thus, the meta-problem ‘Strategic use of knowledge’ is happening to a low extent. One behaviour does not seem to be happening at all and only little evidence of the two other behaviours was found. It can then be concluded that this meta-problem has low significance in this case study.

4.3. THE OPERATIONAL MISFIT BETWEEN DEMAND FOR, AND SUPPLY OF KNOWLEDGE

This meta-problem is composed of four different behaviours: the differences in discourses, goals, and rewards; the differences in timeframes and in level of abstraction; the lack of clarity of the research questions; and the insufficient access to information.

4.3.1. DIFFERENCES IN TIMEFRAMES AND IN LEVEL OF ABSTRACTION

Research takes time to conduct. Knowledge on sewage and on ocean pollution has been produced for years already and some new information is being produced. Scientists think long term when conducting research, they have a long term vision of the problem and of its solutions.

On the other hand, for knowledge users, such as decision-makers, the time frame is different. Politicians are in office for a short time, even more in Curaçao, where the political system is not very stable. On the island, there are more than 15 parties, and the government has changed almost every year the previous years, which does not allow a continuity in the measures. Therefore, users tend to talk about short-time problems and solutions; their consideration of long-term science on the problem is then limited in their decisions-making processes, as they deal with more urgent matters, such as poverty, which can contradicts with the scientific timeframe. It is the same for citizens, or companies, that have more short-term objectives such as paying their bills. The sewage situation is a long term problem, but not perceived as urgent enough by the political world and the civil society. Having sustainable sewage management is therefore not a priority for users.

Regarding the level of abstraction, the interviews revealed that knowledge producers generally communicate with knowledge users such as politicians from the two ministries interviewed,

and sometimes with companies, either during yearly meetings or occasionally to discuss the matter. However, communication can be triggered by users' interests and understanding of the information. Some stakeholders from industries such as tourism, and local residents, so people that are not directly working on sewage, don't necessarily understand the details provided on the issue at hand, which can be too complex for them. Curious2Dive stated that *'many people on the island are not very highly educated so understanding the whole reports can be a problem. People such as engineers should work more with decision makers and other relevant actors so their information can be 'translated' into usable knowledge for politicians and other users.'* The interviewee from Unique Curaçao foundation underlined the fact that *'People need simple language, concrete examples'* to understand the sewage situation. The need to address the topic with real life examples has been underlined several times by different knowledge users. Some complained about the excessive quantity of abstract data and numbers contained in the reports, that makes it difficult to understand. A respondent from the ministry of Health, Environment and Nature also said that a lot of people on the island have a limited education, so there is shortage of skilled labor to study these reports. Another respondent from the same ministry stated that *'the data is not presented in a way that could influence people to make better decisions. Researchers need to adapt their language to people, to raise awareness, to share practical information on how the sewage situation will impact tourism and therefore the economy for example, to present concrete life examples. They need to turn the information in a way people feel concerned directly so they can understand the problem.' Researchers publishing their reports in scientific journals is great, but useless for us.'* The same elements were also mentioned by the Curaçao Tourism board.

Therefore, several pieces of evidence of this behaviour was found. When comparing both producers and users' answers**,** the timeframe for knowledge producers and users appears to be different. Regarding the understanding of the information provided on the topic at hand, it seems that there is a mismatch between the vocabulary used and the ways of presenting things, by scientists and by knowledge users. The information provided seems too abstract, too distant from the practical world, according to users. The low educational level of a lot of people, and the lack of qualified personnel also explain the low understanding of the information provided. I therefore conclude that this type of behaviour occur to an extent that it can be expected to undermine the salience of knowledge produced on sustainable sewage management, and consequently to subsequently jeopardize the uptake of this knowledge.

4.3.2. DIFFERENCES IN DISCOURSES, GOALS, AND REWARDS.

Regarding the discourses on the topic at hand, it is clear that knowledge producers are worried about the sewage situation on the island as they know all the details about it, and the consequences it already has and will have on the reef in the future. They therefore see the situation as very problematic and highlight its urgency. They expect and want their work to improve the sewage situation. However, they deplore the lack of awareness on the issue in the political and civic world. Knowledge producers think that in general, people are more or less aware of the sewage situation on the island and that they don't really care about it because it is an underground problem so no one really sees it. Knowledge producers also regret the lack of political will, of funds available, and of qualified people to deal with the situation.

On the other hand, most of the knowledge users interviewed stated to be aware of the problem as they are either officials working at the ministries, in sewage pick-up or treatment companies, and in environmental consultancy companies. However, the local residents interviewed that are not working in these sectors are usually not aware of the situation, mostly because there is not much information broadcasted on the topic by the government. Thus, knowledge users haven't really mentioned the urgency of the situation. They don't necessarily realise the short term and long term benefits that dealing with the situation would have. Some users might see the situation as problematic for their sector, as the respondent from the Tourism Board said. If the sewage pollution becomes visible to everyone, on land, and in the sea, this may negatively impact tourism. However, this remains a side problem for now. The respondents from the ministries said that there are more urgent matters to deal with, to use the money available for. They also highlight the shortage of qualified people to take care of the situation, and of law enforcement, also caused by a lack of manpower.

Concerning the goal of dealing with the situation, knowledge producers aim to inform the political world and the civil society on the topic, and that way to encourage them to make better decisions and to change their behaviors, in order to preserve the marine environment and at the same time, all the ecosystem services it supports. The reward is therefore a preserved environment, and to see the fruits of their labour.

On the other hand, knowledge users highlight the importance of their objectives, namely developing the island, which can contradict knowledge producers' goals. Policy-makers also want to be reelected so they focus on issues that people are more interested in. However, they

do see the advantages of improving the sewage situation such as less disturbance, such as the bad smell which is emphasized with the heat, mosquitos, and algae on corals and in the water, for instance.

Thus, several evidence of this behaviour was found during the interviews. When comparing producers and users answers, what comes out is that knowledge producers are conducting research on environmental matters and more specifically on sewage in this case, therefore this is a sensitive subject for them, more than for other people that have different interests and concerns such as developing the economy and tourism, dealing with their daily life worries such as paying bills. As a consequence, producers and users understand and perceive the situation, its urgency and its consequences, differently. Scientists highlight the importance of dealing with the problem in order to preserve the environment, but also the livelihoods on the island, in the short and long terms. On the other hand, users see it as a side problem which doesn't have priority, compared to developing the island. The goals and rewards for the knowledge users and producers are therefore different. I therefore conclude that this type of behaviour occur to an extent that it can be expected to undermine the salience of knowledge produced on sustainable sewage management, and consequently to subsequently jeopardize the uptake of this knowledge.

4.3.3. LACK OF CLARITY OF THE RESEARCH QUESTIONS

Decisions-makers know about the sewage problem but communication with knowledge producers is hindered by several elements. Knowledge users don’t necessarily know how to address the problem in a scientifically relevant way because they don’t share the same interests and objectives as knowledge producers, as revealed by the previous behaviours. They tend to focus more on practical questions such as on how to solve the problem in practice, or how much it would cost for instance.

Indeed, the research question of knowledge producers and users are usually not the same which leads to a mismatch between the information demanded and what is produced, and consequently to irrelevant knowledge to solve the problem A respondent from the Ministry of Traffic, Transportation and Urban Planning emphasized their need of solutions being provided by experts, *‘Scientists need to come up with solutions because we know about the problem but*

not necessarily how to deal with it, so we need help with that.'. They also want the financial aspect to be mentioned in the reports, so that science appears more concrete and usable.

On the other hand, the scientists interviewed agreed on the fact that the way the situation is problematized by users, and especially policy-makers, does not necessarily correspond to the type of information they might provide in their reports. They have to remain academically correct, give detailed scientific data on the situation, and do not necessarily know enough on the financial aspects of the problem or on the possible fitting solutions for the case study.

The difference in levels of abstraction, timeframes, and vocabulary, between users and producers, as revealed by the presence of other behaviours of the operational misfit meta-problem, also complicate the formulation of research questions by users, that are relevant for scientists.

An interviewee from the Ministry of Health, Environment and Nature highlighted that knowledge users and producers need to work more together in a constructive way in order to to be on the same page regarding the type of knowledge to be produced.

Thus, the research questions seem to lack clarity, leading to a mismatch between what information is provided and what is demanded. The information provided doesn't necessarily fit what knowledge users need because the interests of both stakeholders are different, therefore the formulations of the problem are also different. Thus, some evidence of this behaviour was found. I therefore conclude that this type of behaviour occur to an extent that it can be expected to undermine the salience of knowledge produced on sustainable sewage management, and consequently to subsequently jeopardize the uptake of this knowledge.

4.3.4. INSUFFICIENT ACCESS TO INFORMATION

This behaviour only concerns knowledge users. What came out of the exploration of this behaviour, is that politicians are aware of the reports available and have access to them, notably because they finance some research centers such as Carmabi to conduct research on various topics ; and because they also work together sometimes, or at least communicate with some knowledge producers, such as in the Committee for Integrated and Sustainable Water Management, composed of officials from the government and experts, from NGO notably.

However, people from industries or local residents, are not necessarily aware of the scientific information provided on the topic at hand unless they are given the information directly, and don't necessarily know where to access it. For instance, one of the local residents interviewed said '*I heard once on the radio that there are some spots where sewage is going into the sea, but I thought that there was some type of filtration.*' Therefore, little information is broadcasted on the topic, as it is not a priority issue on the island.

Thus, the scientific knowledge produced on the topic at hand is accessible to policy-makers, to companies, but less easily accessible to local residents or people working in other sectors. This behaviour scores mediumly as it depends on the stakeholders : locals have a hard time accessing the information, while it is easier for politicians or companies. I therefore conclude that this type of behaviour occurs to an extent that it can be expected to undermine the salience of knowledge produced on sustainable sewage management,, and consequently to subsequently jeopardize the uptake of this knowledge.

4.3.5. CONCLUSION

Therefore, the meta-problem 'Operational misfit between the demand for, and supply of knowledge' is happening to a high extent. Almost all the behaviours of that meta-problem score high, which means that the scientific knowledge provided on the topic at hand lacks salience notably because of the operational misfit between the demand for, and supply of knowledge.

4.4. CONCLUSION OF THE RESULTS

In conclusion, seven out of the six behaviours investigated have been observed, but to different extent. The operational misfit between demand for, and supply of knowledge is highly significant for this case study, contrary to the strategic use of knowledge. Table 5 below summarizes the score of results from the behaviours analysis.

Meta-Problem	Behaviour	Score
Strategic use of knowledge (affects salience, legitimacy, credibility)	Knowledge is deliberately ignored.	Little evidence
	Knowledge is selectively used.	Little evidence
	The use of counter expertise in order to disqualify contested knowledge.	No evidence
Operational misfit between demand for, and supply of knowledge (affects salience)	Differences in timeframes & in level of abstraction regarding the sewage problem.	Much evidence
	Differences in discourses, goals, and rewards.	Much evidence
	The lack of clarity of the research questions.	Much evidence
	Insufficient access to information.	Some evidence

Table 5. Behaviours score

5. DISCUSSION & CONCLUSION

5.1. DISCUSSION OF THE RESULTS

What can be said, when looking at the results, is that some indicators scorre better than others. The behaviours associated with the strategic use of knowledge score low on average. Only little evidence was found for two of them and one is not happening at all. I therefore conclude that the meta-problem 'Strategic use of knowledge' doesn't seem to occur to an extent that it can be expected to undermine the credibility, legitimacy, or salience of knowledge on sewage management, and therefore to subsequently jeopardize the uptake of this knowledge. This aligns with the assumption made in the conceptual framework, that the knowledge produced on sewage pollution and its impact on the reef is presumed legitimate and credible. Indeed, this meta-problem affects, beside salience, the credibility and legitimacy of knowledge, but as it is not happening in this case study, it can be concluded that these two criteria are already met as there are no proof of behaviours that undermine them both.

On the other end, the behaviours associated with the 'Operational misfit between demand for and supply of knowledge' all score rather high, which confirms the interest for the focus of this research, namely the salience of the knowledge produced on sustainable sewage management, as this meta-problem undermines salience specifically. In other words, in this case study, the salience of knowledge on sustainable sewage management is principally undermined because of an operational misfit between demand for, and supply of this knowledge.

What could consequently be concluded is that the meta-problem 'Operational misfit between demand for, and supply of knowledge' seems to be the main obstacle to salience of scientific knowledge in general; and that the meta-problem 'Strategic use of knowledge' is not an actual barrier to that criterion, but to credibility and legitimacy only.

The importance of the meta-problem of the operational misfit as an obstacle to research uptake, and more specifically to salience, is supported by the literature. It is a recurrent problem in the science-practice relationship, notably regarding environmental issues. Indeed, the difference between the timeframes of science and of the political world, and the level of abstraction, is a common problem as scientists and knowledge users don't live in the same world, they don't

use the same vocabulary, and don't have the same issues to deal with. It is the same concerning the differences in discourses, goals and rewards. Knowledge producers and users don't necessarily see environmental issues and their impacts from the same perspective. Therefore, unclear research questions arise. Regarding the access to information, it is not surprising that locals are not fully aware of certain problems. If environmental problems do not have the priority, not much information is broadcasted on the matter by the government or the media. All these behaviours hinder the communication and work between the two spheres, and mostly lead to irrelevant science for users.

Another remark regarding the behaviours from Van Enst et al. (2014) framework, is that some of them lead to similar findings when being explored on the field. For example, investigating the 'differences in discourses' give comparable information than the behaviour 'differences in timeframes and level of abstraction'. For both, people mentioned how urgent the sewage situation is according to them, for instance. Also, the degree of people awareness was mentioned several times when exploring the 'differences in discourses' and researching the behaviour 'insufficient access to information' for example. Thus, it was sometimes complex to clearly analyze the answers to the interview questions.

Finally, what appeared in the interview, is that there are no proper stimuli to research uptake, that could increase salience, in this case study. There are few elements to stimulate the communication and work between decision-makers, citizens and academics, such as the Committee for Integrated and Sustainable Water Management composed of officials and experts working together; and educational programs by Carmabi for instance to inform children on nature protection and the threats to it such as pollution from the land. Some other events such as public movie nights with documentaries or conferences about environmental issues also contribute to people's education. However, overall, there are no specific strategies to improve the use of science.

5.2. CONTRIBUTION TO SCIENCE & SOCIETY

The results of this research serve the project of SEALINK. First, this project provides a map of the relevant stakeholders that affect sewage on the island. Second, it delivers information on what hinders the uptake of research about sustainable sewage management, so researchers can

adapt their work to make it more salient for users, by overcoming the operational misfit, in order to ensure that their data will be considered.

Furthermore, the framework of Van Enst et al. (2014) proved its relevance, to a certain extent, as it allowed me to explore the behaviours leading to a lack of salience and have pertinent results. However, the findings also add some nuances. Indeed, as mentioned previously, it appears that the Operational misfit between demand for, and supply of, knowledge, is the most significant obstacle to salience. Indeed, the Strategic use of knowledge scores low on average while the Operational misfit scores high. A whole meta problem is therefore not appearing so the framework could reconsider the importance of the strategic use of knowledge as a meta-problem that jeopardizes salience. Thus, future researchers should focus on the operational misfit and its associated behaviours when they are studying the salience of knowledge. Moreover, as mentioned previously, certain findings from different behaviours, are similar, to some extent. It could therefore be interesting to reconsider some of the behaviours, such as the 'differences in discourse' which is a bit vague and can bring quite diverse answers.

This research therefore challenges and feeds research on the relationship between science and practice by emphasizing the importance of salience as a criterion that knowledge needs to meet for optimal research uptake, and on the significance of the operational misfit problem as the main obstacle to salience. It also gives insights on the research framework that was used.

Moreover, these results give some keys to improve the sewage situation on the island as it will hopefully enable a better cohesion between knowledge users and producers, so better decisions can be taken regarding sewage, and therefore sustain the reef and all the services it supports. Indeed, the findings clearly show that the scientific and the 'practical' worlds are two distinct spheres, and that some work needs to be done for a better consistency between both.

Finally, the results of this research could be extrapolated to other case studies of research on sewage, but also on any other environmental issue research. Indeed, the meta-problem 'Operational misfit between demand for, and supply of knowledge, is, as mentioned previously, supported by the literature, and seems to be a recurrent problem in the science and practice relationship.

5.3. LIMITATIONS & REFLECTIONS ON THE METHOD

What critical reflection that can be made is that reports and data on sewage do exist but the biggest study is being done by the SEALINK project, which has just started. Therefore the knowledge being produced on sewage pollution and its impact on the reef is ongoing. Exploring the salience, so the relevance, of a knowledge that is being produced, can seem irrelevant. However, conducting this research was still pertinent as it gives several insights on the salience of the knowledge produced so far, so current researchers can consider doing things differently when conducting their research.

Regarding the stakeholders that were interviewed, more local residents could have been interviewed to have a more comprehensive way of what they know about the sewage problem, and on how they perceive the situation for instance. However, they don't necessarily speak English and it is harder to reach them as they have to be approached spontaneously. Nevertheless, talking to a few already gave information on their knowledge and opinion on the matter at hand. Also, the list of interviewees was made as diverse as possible to represent all the possible relevant stakeholders for this research, even if more locals could have been interviewed, so the representativeness is fulfilled as well.

Another reflection concerns the behaviours that were studied in this case study, other ones that were not explored in this case study, and not mentioned by Van Enst et al. (2014), could be happening. There are a lot of studies on research uptake and other authors mention different conditions that can contribute to research uptake, but that were left out in this research. This research is limited to the seven behaviours that affect salience. Studying more elements would have been too long. However, the interviews were semi-conducted in order to gather possible information that were not necessarily mentioned in the literature and in the questions lists, did not reveal any new behaviour, which confirms the relevance of Van Enst et al. (2014) framework. Therefore, the research method is pertinent because the behaviours used as indicators are well-grounded. They allowed me to expose the problems undermining the salience of the knowledge produced on sustainable sewage management, and to feed research on that topic at the same time. Indeed, as mentioned in the previous section, the research revealed that that the operational misfit is clearly more relevant to study the salience of science, so future researchers should focus on that meta-problem if they are focusing on salience.

5.4. RECOMMENDATIONS

The results show that the scientific knowledge produced on the topic at hand lacks salience because of an operational misfit between the demand for, and the supply of knowledge. Based on the findings, recommendations to further researchers are following, on how to overcome this operational misfit and its associated behaviours. They consist of preliminary findings based on a literature review on solutions to overcome that operational misfit and on the suggestions on how to improve research uptake made by some stakeholders during the interviews. By doing so, this section also answers the third and last sub-question 'How can the uptake of scientific knowledge regarding sustainable sewage management in Curacao be improved ?'.

Van Enst et al. (2014) propose, as solutions to increase research uptake and notably to overcome the operational misfit, 'science-policy interfaces', which are understood as 'social processes which encompass relations between scientists and other actors in the policy process, and which allow for exchanges, coevolution, and joint construction of knowledge with the aim of enriching decision-making' (p.13). They encompass: an individual science-policy mediator, a boundary organisation, and the process of participatory knowledge development. They all aim to bridge the gap between science and practice, and emphasize the need for knowledge producers and users to work together, to create a common knowledge that would fit both, to translate and share ideas from one world to the other. These solutions have been researched a lot, however no definite answer to the question 'What works where, when and how?' have been found yet (Van Enst et al., 2014). Further research is needed to know exactly what strategies fit which behaviours the best, and how to actually implement them.

Other authors such as McNie (2006) agree with Van Enst et al. (2014) and consider all these solutions pertinent to reconcile the demand and supply of knowledge. Policy makers at the global scale are calling for the creation and transmission of more useful and practical information for environmental decision-making, as 'useful information expands alternatives, clarifies choice and enables policy makers to achieve desired outcomes' (McNie, 2006, p.1). However, this type of information is often lacking. Too much of the wrong information can be produced. Nevertheless, as revealed by the results, there are some obstacles to the creation of knowledge that is salient enough to be used. Some elements mentioned during the interviews support these solutions. Several stakeholders pointed out the necessity to adapt the information

provided, to the different users, and the need to have more joint work and knowledge production.

Therefore, creating a common understanding of the problem and a common knowledge, by working together and collaborating more, appears to be the best approach to increase the salience of the knowledge produced by overcoming the operational misfit between the demand for, and the supply of knowledge, and consequently to have optimal research uptake. Such a process is also named ‘co-creation’ or ‘co-production’, or sometimes joint knowledge production in other articles. Much research is being conducted on that topic. It entails reuniting stakeholders with opposite interests and visions, to determine the information that all stakeholders consider pertinent and trustworthy (Karin et al., 2021). This maximizes the chance that knowledge will be dissociated from personal interests. Karin et al. (2021) highlights that, to facilitate the creation of relevant scientific information and therefore political action, researchers have to encourage a transdisciplinary approach where knowledge users and producers ‘interact to co-create knowledge that is actionable in decision-making’ (p.2). It has been proved useful ‘not only for adaptating decision-making, but for fostering mutual understanding and learning, enhancing the perceived saliency, credibility, and legitimacy of research outcomes; empowering users, motivating them, and increasing their sense of ownership; building trust, creating networks, and boosting institutional capacity’ (p.2). Co-production therefore rejects the fact that ‘scientists alone identify the issue, research the problem, and then deliver knowledge to society, in favour of more interactive arrangements between academic and non-academic actors. Co-production processes produce more than just knowledge; they develop capacity, build networks, foster social capital, and implement actions that contribute to sustainability.’ (Norström et al., 2020, p.182-183).

Further research is therefore needed to study how to implement co-production of knowledge on the topic of sewage pollution and the impact it has on the reef, in the Curaçao context, in order to overcome the operational misfit between demand for, and supply of knowledge, and consequently to have optimal research uptake.

5.5. CONCLUSION

This study aimed at exploring 'What hinders and what helps the uptake of scientific knowledge about sustainable sewage management by relevant stakeholders in Curaçao?'.

Science plays a primary role in sustainable development and in ecosystem conservation, such as for coral reefs, by providing information to the public, but it is not necessarily uptaken. According to the literature (SQ1), knowledge needs to be salient, credible, and legitimate to be used in decision-making processes. Salient is the key factor that was looked at in this case study as the two other criteria were presumed to be covered already. It refers to knowledge being relevant for users and fitting their needs so they can consider the knowledge produced in their decisions.

To study the extent these factors apply to the case of sewage management in Curaçao (SQ2), the behaviours associated with the meta-problems leading to a lack of salient knowledge on sewage pollution and the impact it has on the reef, were explored during field work on the island, through semi-structured interviews of the knowledge users and producers. What has been found is that the knowledge produced on the topic at hand, lacks salience, mostly because of an operational misfit between the demand for, and the supply of knowledge. It encompasses fours behaviours that all score high in average in this case study: the differences in timeframe and level of abstraction, the differences in discourses, goals, and rewards, the lack of clarity of the research question, and the insufficient access to information. This operational misfit is a recurrent problem in the science and practice relationship. Indeed, the results, supported by the literature, show that the way science is produced is often criticized by knowledge users, as in this case study, for not meeting their needs. This can create resentment among users and producers. Scientists are frustrated that no policy change is happening, and policymakers feel baffled as scientific knowledge does not necessarily answer their policy questions and problems.

This research therefore feeds and challenges research on the science-practice relationship, by emphasizing the importance of salience, for an optimal research uptake, and of the operational misfit problem as the main obstacle to salience.

To overcome this operational misfit (SQ3), literature suggests solutions such as science-policy interfaces which encompass having a mediator between producers and users of knowledge to

facilitate communication, a boundary organisation where all relevant stakeholders can work together, and especially the creation of common knowledge so that the science produced remains relevant for scientists and is pertinent enough for users to be considered in their decision-making processes. Much research is already being done on knowledge co-production, seen as a key approach to improve the science and practice relationship, but further studies are necessary to implement it in the context of Curaçao, to improve the sewage situation.

References

Adams, W.C. (2015). Conducting Semi-Structured Interviews. In K.E. Newcomer, H.P. Hatry, J.S. Wholey, (Eds.), *Handbook of Practical Program Evaluation* (p.492-505). Jossey-Bass.

Adshead, D., Fuldauer, L., Thacker, S., Hickford, A., Rouget, G., Muller, W.S., Hall, J.W, Nicholis, R. (2018). Evidence-based infrastructure: Curaçao. National infrastructure systems modelling to support sustainable and resilient infrastructure development. *United Nations Office for Project Services*, Copenhagen, Danemark https://www.itrc.org.uk/wp-content/uploads/2019/09/UNOPS-ITRC_EBI_Curacao_2018-Full-report.pdf

Bryson, J.M. (2004). What To Do When Stakeholders Matter: A Guide to Stakeholder Identification and Analysis Techniques. *Public management review*, *6*(1), 21-53. DOI:10.1080/14719030410001675722

Cash, D., Clark, W.C., Alcock, F., Dickson, N.M., Eckley, N., Jäger, J. (2003). Salience, Credibility, Legitimacy and Boundaries: Linking Research, Assessment and Decision Making. *KSG Working Papers Series.* http://nrs.harvard.edu/urn-3:HUL.InstRepos:32067415

DCNA. (2016, May 13). *Coral Reef Rehabilitation in the Dutch Caribbean.* Dutch Caribbean Nature Alliance. https://www.dcnanature.org/coral-reef-rehabilitation-in-the-dutch-caribbean/

Ingram, J., Mills, J., Dibari, C., Ferrise,R., Ghaley, B.B., Hansen, G.,H., Iglesias, A., Karaczun, Z., McVittie, A., Merante, P., Molnar, A., Sánchez, B. (2016). Communicating soil carbon science to farmers: Incorporating credibility, salience and legitimacy, *Journal of Rural Studies, 48*, 115-128, https://doi.org/10.1016/j.jrurstud.2016.10.005.

Johnson, T. & Lerner, J.Y. (2021). Environmentalism among poor and rich countries: using natural language processing to handle perfunctory support and rising powers. *Review of International Political Economy*, DOI: 10.1080/09692290.2021.1974523

Karin, A., Järnberg, L., Gerger Swartling, A., et al.(2021). Assessing the Quality of Knowledge for Adaptation–Experiences From Co-designing Climate Services in Sweden. *Frontiers in Climate, 3* https://doi.org/10.3389/fclim.2021.636069

Kunseler, E.M., Tuinstra,W., et al. (2015). The reflective futures practitioner: Balancing salience, credibility and legitimacy in generating foresight knowledge with stakeholders. *Futures, 66*, 1-12 https://doi.org/10.1016/j.futures.2014.10.006

Malaria Consortium. (2016). Guide to developing and monitoring a research uptake plan. https://www.malariaconsortium.org/media-downloads/799

McNie, E.C. (2017). Reconciling the supply of scientific information with user demands: an analysis of the problem and review of the literature. *Environmental science & policy, 10*, 17–38 doi:10.1016/j.envsci.2006.10.004

Niederberger, A.A. (2005). Science for climate change policy-making: applying theory to practice to enhance effectiveness. *Science and Public Policy, 32*(1), 2–16 https://www.researchgate.net/publication/279699495_Science_for_climate_change_policy-making_Applying_theory_to_practice_to_enchance_effectiveness

NIOZ. (n.d). *€ 3,5 million awarded for Dutch Caribbean coral reef research.* Royal Netherlands Institute for Sea Research. Retrieved January 7, 2021 from https://www.nioz.nl/en/news/eur-35-million-awarded-for-dutch-caribbean-coral-reef-research

Norström, A.V., Cvitanovic, C., Löf, M.F. et al. (2020) Principles for knowledge co-production in sustainability research. *Nature Sustain*ability, 3, 182–190. https://doi-org.proxy.library.uu.nl/10.1038/s41893-019-0448-2

Panisset, U., Koehlmoos, T.P., Alkhatib, A.H. et al. (2012). Implementation research evidence uptake and use for policy-making. *Health Research Policy and Systems*, *10*(20) https://doi-org.proxy.library.uu.nl/10.1186/1478-4505-10-20

Pastorok, R.A., Bilyard, G.R. (1985). Effects of sewage pollution on coral-reef communities. Marine Ecology - Progress Series, 21, 175-189, DOI:10.3354/meps021175

Pohl, C.(2008). From science to policy through transdisciplinary research. *Environmental science & policy, 11*, 46–53, doi:10.1016/j.envsci.2007.06.001

Reed, M., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., Prell, C., Stringer, L. C., & Quinn, C. H. (2009). Who's in and why? A typology of stakeholder analysis methods for natural resource management. *Journal of Environmental Management, 90*(5), 1933-1949. https://doi.org/10.1016/j.jenvman.2009.01.001

Runhaar, H.A.C., Van der Windt, H.J., Van Tatenhoved, J.P.M. (2016). Productive science–policy interactions for sustainable coastal management: Conclusions from the Wadden Sea area. Environmental Science & Policy, 55(3), 467-471 https://doi.org/10.1016/j.envsci.2015.09.002

Van Enst, W. I., Driessen, P. P., & Runhaar, H. A. (2014). Towards productive science-policy interfaces: a research agenda. *Journal of Environmental Assessment Policy and Management, 16*(01), 1-25. https://doi.org/10.1142/S1464333214500070

Van Voorn, G.A.K., Verburg, R.W., Kunseler, E.-M., Vader, J., Janssen, P.H.M. (2016). A checklist for model credibility, salience, and legitimacy to improve information transfer in environmental policy assessments, *Environmental Modelling & Software, 83*, 224-236, https://doi.org/10.1016/j.envsoft.2016.06.003

Vermeij, M. (2021). THE SEALINK PROJECT. Sealink Caribbean. https://www.sealinkcaribbean.net

Waitt Institute (May 2017). Marine scientific assessment. The State of Curaçao's Coral Reefs. https://www.dcbd.nl/sites/default/files/documents/Marine-Scientific-Assessment_May-2017-Part1.pd

Woodhead, A.J., Hicks, C.C., Norström, A.V., Williams, G.J., Graham, N.A.J (2019). Coral reef ecosystem services in the Anthropocene. *Functional Ecology, 33(*6), 1023-1034 https://doi.org/10.1111/1365-2435.13331

Appendix

Interviews questions

→ For Knowledge producers

1. If applicable, what is the mission of your organization?
2. If applicable, can you please elaborate on your role (or that of your organization) in the storing, transporting, treatment and/or discharge of sewage?
3. It is known that in the process of producing, storing, transporting, treating and/or discharging sewage, the environment can be impacted. Based on your experience, could you please elaborate on the details and the extent to which that is the case in Curacao?
4. Do you personally experience any of the negative impacts that we discussed in follow up to the previous question?
5. Earlier, we have discussed the potential impact of the way sewage is handled on the environment. It has been suggested that it can also impact the island's coral reef. What do you know about this? Do you think that people in the island in general have awareness about this?
6. Since when research is going on the impact of sewage pollution on the marine ecosystems on the island?
7. Is there anything that you (or the organization that you represent) do to minimize or even avoid that impact?
8. Can you tell me about the challenges you might have experienced regarding these actions?
9. Which of these challenges is the most important and the hardest to overcome, according to you?
10. Do you think that other stakeholders (e.g., in agencies/ministries, policy making, politics, industry, tourism, residents) see the challenges related with sewage in the same way as you do? Explain.
11. Are there any stakeholders you communicate with in that situation? And do you find it difficult to communicate with them about it? What could improve this communication according to you?
12. Which governmental department carries the responsibility of dealing with sewage transport, treatment, discharge?

13. Who do you think should be involved in decision making about tackling sewage related challenges? (Experts, policy makers, politicians, industry, residents, etc.)
14. How important is sewage management and the related challenges on the political agenda according to you?
15. How urgent is it according to you to tackle the challenge(s) that we have been discussing so far? How much priority should it have, compared to other pressing challenges that the island faces?
16. How would solving the challenge that you mentioned benefit you or your organization? How would it benefit the island and the islanders, broadly defined?
17. As a researcher/academic/NGOs/scientist/ are you being asked to produce information on that environmental issue or not? If yes, what type of information and under which format?
18. Does it correspond to the type of information & format that you would produce originally?
19. Do you think that the type of information that you produce on that issue is enough for making better decisions, and/or to take action to tackle the challenge more effectively?
20. To what extent do you feel that other relevant stakeholders (e.g., in agencies/ministries, policy making, politics, industry, tourism, residents) make use of such knowledge? Do you think that in general they use such knowledge to a sufficient extent, or is there room for improvement?
21. Are you aware of the existence of any counter-expertise that contradicts with the knowledge that you produce on the sewage pollution problem/ any evidence that contradicts you? If yes, which one?
22. What is being done that you know of that is meant to increase or facilitate the use of the kind of knowledge that we have been discussing?
23. Could you think of ways to improve the extent to which this knowledge is used for the tackling of the kind of challenges that we have been discussing by yourself and other relevant stakeholders?
24. Who else do you think participates in the sewage process and what is their role & sector?
25. Would you like to stay up to date with my research?

→ For Knowledge users

1. If applicable, what is the mission of your organization?
2. If applicable, can you please elaborate on your role (or that of your organization) in the storing, transporting, treatment and/or discharge of sewage?
3. It is known that in the process of producing, storing, transporting, treating and/or discharging sewage, the environment can be impacted. Based on your experience, could you please elaborate on the details and the extent to which that is the case in Curacao?
4. Do you personally experience any of the negative impacts that we discussed in follow up to the previous question?
5. Earlier, we have discussed the potential impact of the way sewage is handled on the environment. It has been suggested that it can also impact the island's coral reef. What do you know about this? Do you think that people in the island in general have awareness about this?
6. Still on the topic of the potential impact of how sewage is handled on the environment (both on land and in the ocean). Is there anything that you (or the organization that you represent) do to minimize or even avoid that impact?
7. Can you tell me about the challenges you might have experienced regarding these actions?
8. Which of these challenges is the most important and the hardest to overcome, according to you?
9. Do you think that other stakeholders (e.g., in agencies/ministries, policy making, politics, industry, tourism, residents, scientist) see the challenges related with sewage in the same way as you do? Explain.
10. Are there any stakeholders you communicate with in that situation, and do you find it is difficult to communicate with them about it? What could improve this communication according to you?
11. Which governmental department carries the responsibility of dealing with sewage transport, treatment, discharge?
12. Who do you think should be involved in decision making about tackling sewage related challenges? (Experts, policy makers, politicians, industry, residents, etc.)
13. How important is sewage management and the related challenges on the political agenda according to you.

14. How urgent is it according to you to tackle the challenge(s) that we have been discussing so far? How much priority should it have, compared to other pressing challenges that the island faces?
15. How would solving the challenge that you mentioned benefit you or your organization? How would it benefit the island and the islanders, broadly defined?
16. Is the information that is currently provided about the challenge(s) that we have been discussing enough for making better decisions, and/or to take action to tackle the challenge more effectively?
17. Are you aware of any research that is being done, or that is available on the challenge we have been discussing, and/or on the way(s) to tackle it? And to what extent would you say you are familiar with the details about it?
18. Are you able to easily find information on this issue and if yes, how? And do you find that the information available on this situation in general is clear, and accessible to all?
19. To what extent do you make use of such knowledge?
20. To what extent do you feel that other relevant stakeholders (e.g., in agencies/ministries, policy making, politics, industry, tourism, residents) make use of such knowledge? Do you think that in general they use such knowledge to a sufficient extent, or is there room for improvement?
21. Regarding this knowledge that we have been discussing, is it your impression that the type of knowledge that is relevant for you or your work is credible? Or to the contrary, is it contested? Can you elaborate?
22. What is being done that you know of that is meant to increase or facilitate the use of the kind of knowledge that we have been discussing?
23. Could you think of ways to improve the extent to which this knowledge is used for the tackling of the kind of challenges that we have been discussing by yourself and other relevant stakeholders?
24. Who else do you think participates in the sewage process and what is their role & sector?
25. Would you like to stay up to date with my research?