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RESEARCH ARTICLE

Nature based solutions for flood risks: What insights do the social representations of experts provide?

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Abstract

In the context of intensification of flood risks, Nature Based Solutions constitute an interesting approach to conciliate population's protection and biodiversity. While this recently emerging concept has been the subject of studies in social sciences, there is no work yet with a social representation approach. In this work, we propose to study Nature Based Solutions for flood risk management through the prism of social representations and how they frame the implementation of Nature Based Solutions projects in the field (obstacles and levers). We interviewed 19 flood experts who can be divided into two groups regarding Nature Based Solutions: theorists and practitioners. We studied their discourses using two types of analyses: a lexicometric analysis of the similarities and a thematic analysis. The results showed that Nature Based Solution is a social representation object in its complexity, the polarisation it creates and its technicality. The two groups of participants have different representations. The practitioners may consider the Nature Based Solutions as "green-washing" since they are presented as new and innovative, while the theorists contrast their Nature Based Solutions' vision with a "grey" vision influenced by French civil engineering culture and a need to control ecosystems. Both groups agree that Nature Based Solutions thinking is about "leaving more room for nature", which echoes Dunlap's New Environmental Paradigm. Moreover, the results suggest that the expression "Nature Based Solutions" is not well suited to all actors. We encourage using the expression "vegetal engineering" which may provide an opportunity to reconnect with the techniques applied in the field. It also enhances the value of ancestral knowledge, which allows the general public to better connect with the concept.

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Introduction

1. Nature based solutions for flood risk

One of the major challenges of the Anthropocene era is undoubtedly human adaptation to climate change. Climate change has impacts on many phenomena and in particular on the

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frequency and intensity of extreme climatic events such as floods [1]. In France, flooding is the main natural hazard [2]. To protect exposed populations, many solutions, both structural (e.g., dikes) and non-structural (e.g., risk prevention plans), exist and are implemented in the field. Civil engineering infrastructures, also called “grey” solutions (dikes, flood control dams, etc.), are historically very well developed in France. In addition, the concept of Nature Based Solutions (NBS) represents an adaptation strategy to address current climate challenges [3] such as flooding. It has emerged in 2009 under the impetus of IUCN (International Union for the Conservation of Nature), at the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) [4]. NBS thus can be conceived as a relatively recent concept originating in the scientific sphere. NBS can be defined as “actions to protect, sustainably manage, and restore natural or modified ecosystems to directly address societal challenges in an efficient and adaptive manner, while ensuring human well-being and producing biodiversity benefits” [5]. Thus, these solutions seek to serve at the same time society and the natural environment. There are many examples of NBS that can mitigate the impact of flooding such as retention ponds, wetland restoration or rain parks. A retention pond is a basin intended to temporarily store water to prevent flooding downstream in the catchment area; this water can be gradually infiltrated towards the groundwater. Wetlands play a leading role in capturing carbon and in the water cycle in general; restoration ensures that they retain their function. A rain park is an urban park in which a portion is designed to receive water during a flood; by capturing some of the runoff, it limits flooding while avoiding the need for concrete constructions. The risk of flooding is higher in urban areas where urbanization and soil sealing are drastically increasing [6], which can lead to greater runoff, thus aggravating the risk of urban flooding [7]. Research shows that “grey” solutions such as levees, which are traditionally used in Western cities, no longer always have the capacity to keep pace with the increasing rate of stormwater [8, 9]. Moreover, these “grey” solutions usually only address the sole objective of protection whereas NBS can be multifunctional. Indeed, they contribute to the adaptation to climate issues, as well as to biodiversity and human well-being, while providing an effective response to the protection of populations from flood risk [10, 11]. Several territories have already experimented with the use of NBS for flood risk management; these examples are documented and reviewed in the literature [12, 13]. Examples include re-meandering to restore the original course of a stream to dissipate its energy or vegetating the slopes of a basin to reduce and slowdown runoff.

The NBS concept has been adopted by the European Commission in its “Horizon 2020” research program to promote the development of NBS in urban areas [14]. In France, various institutions have adopted it, such as INRAE (National Research Institute for Agriculture and Environment) [15] or OFB (French Office for Biodiversity) [16]. Although social sciences have recently studied this concept under the angle of public acceptance [17] or perception [18], this concept has not been studied yet with the Theory of Social Representation (TSR) approach. This is the aim of the present study. Indeed, the TSR is particularly interested in understanding how a concept proposed by science is received, understood and transformed in social thought and common sense. TSR is not interested in measuring a “correct” perception or knowledge, but how a social object makes sense for a social group [19]. This comprehension is of undeniable value for participative risk management [20].

2. Nature based solutions as an object of social representations

Social psychologist Serge Moscovici proposed the TSR in 1961 [21]. He studied social thought and analyzed how “psychoanalysis”, was received and understood by different groups in French society (in this case Catholics and Communists). He showed the sociogenesis of Social

Representation (SR): both groups had developed and socially constructed their own representations of psychoanalysis, coherent with their own universe of ideas, values and symbolic associations. SRs help to understand and manage the environment, they are tools guiding thinking and behaviour. SRs are constructed by two associated processes: objectivation and anchoring [22].

The first refers to a principle of cognitive coherence, while the second responds to a need to reduce uncertainty. Objectivation consists in transforming vague beliefs or information into certainties, so that these elements no longer appear as the product of the cognitive activity of the person who holds them, but as the reflections of an objective external reality [23].

Associated to objectivation is anchoring. By assimilating a new or unknown object into a familiar category linked to familiar values and standards, the object becomes meaningful. To identify a social representation is thus to study what individuals think about an object, how they use it and how they integrate it in the formulation of their common reality [24]. Since its initial formulation and the interest for the sociogenesis of social representations, i.e., how they come into being, the TSR has tremendously developed, and beside the sociogenetic approach, three other approaches can be distinguished [25, 26]. The structural approach which studies the structure and content of SR [27]; the socio-dynamic approach which concentrates on the role played by the social position on SR [28] and the dialogical approach which concentrates on the role played by language and communication in SR development [29]. These approaches are, as [30] underlined, complementary. Consequently, we have articulated our thought to all four approaches to some extent. We are interested in the socio-genesis of the SR of a “new” technico-scientific concept, NBS, and analyse it through lexicometric analysis (see [method](#) section) which allows us to see its content and structure [31]. We analyse this SR in a specific social group, flood experts, and we are particularly attentive to the dialogical nature of SR, in other words, to the fact that when somebody talks about a thought object (such as NBS), he or she does so by taking into account the other [32]. This seems to us especially important with a group of experts who do research about NBS or work to implement them on the field (see below). A SR is therefore not just the single vision that a group has of a social object, but a representation that incorporates the knowledge of others who may have a different point of view [33]. Moreover, SR are not independent from each other, they are in interaction and influence each other in various ways [26]. This is consistent with the anchoring process, making new objects familiar, and therefore we can expect that the SR of NBS is included or at least discussed within the SR of nature and environment.

3. Related concepts

Nature as an object of social representation has been studied extensively. Serge Moscovici, in his essay on the history of nature, explains that humans have never given nature a constant representation. It has evolved through the ages precisely according to the relationship between human societies and nature. He describes nature as organic in the days of farmers and craftsmen, mechanistic during the industrial era and nowadays cybernetic. These different representations are involved in the very social construction of nature [22] and are synchronous, distinct and interdependent [34]. Each of them is intrinsically linked to a particular sense of identity, a mode of knowledge and a mode of relation to nature [35]. This polysemy of nature has also been described at length by Descola [36], who explains that “nature” is a Western concept invented to differentiate human culture from the rest of living beings. Close to the term nature, the notion of environment is very broad and is also used in many contexts [37]. The very definition of environment leaves much room for interpretation: indeed, Sauvé [38] described six representations of the environment: the environment as a resource, a problem, a

place to live, a biosphere, a community project and as nature. These six paradigmatic conceptions are at the heart of a singular representation of the environment [39]: they are complementary and coexist [40]. Some authors invoke a utilitarian vision as opposed to an ecological vision of the environment [41, 42]. We believe that these visions build a common ideological basis for a set of social representations of other environmental objects, such as NBS [21].

Like nature and environment, the term NBS is polysemous, and the definition given earlier allows many different interpretations as to what actions should be undertaken. We consider it as a new technical-scientific object [21] that might trigger different conceptions in individuals. It is a term that brings about debate: it can be praised as much for its qualities [4] as criticized for the vagueness of its very englobing definition [9, 43] and the lack of evidence by example that accompanies its principle [44]. The media and institutions that speak about NBS describe them as innovative, embodying high environmental values and whose co-benefits could revolutionise the current approach to flood risk [5, 15]. We observe some debate around this concept which is a condition for the emergence of a social representation [45]. Another condition is that the object must be a matter of interest, interaction and communication between individuals in their given social group [45]. This is why we concentrated this study on a specific group: experts of flood risk.

4. Social representation of experts

The difficulties of apprehending new objects based on scientific findings is quite common [29, 46]. It concerns the general public but can also involve experts themselves. In this article, we focus on exploring social thought around NBS in a group of flood risk experts. They are supposed to develop and implement solutions to flood risk in the French territory, NBS being one possible solution. In France, this category of people can look back to a long French tradition of management of nature by engineering, especially through the “Ingénieurs des Ponts et Chaussées” (“Bridges and Roads Corps”) [47], trained and missioned by the French State to apply its objective to develop the country and prevent natural risk since the 18th and particularly the 19th century [48]. We expect that this historical culture of civil engineering in France will influence the vision of the experts involved and fuel debate about NBS. Indeed, traditionally, engineering had a will of mastery of nature [49], but nowadays, in the anthropocene [50], the ideology concerning the stewardship of nature might be less dominant [51]. We think that the question of the relation to nature and to risk will frame the social representation of NBS [34].

Moreover, it is assumed that the opinions of experts eventually diffuse and come to shape the representations of the general public [52]. It is interesting to study the social representations of experts for this reason as well. At the same time, the social representations of experts are not always uniform [52]. Since we wanted to scan the broadest and most representative sample of professions, we interviewed various types of flood experts, whom we divided into two groups: theorists and practitioners. Theorists are institutional and/or scientific actors and researchers, who are not necessarily close to the field. They do not implement NBS or other flood protection devices in the territory and are supposed to have a rather theoretical and philosophical view of the concept. The practitioners are the technical actors in the field (e.g., river basin coordinators), who have the technical knowledge to implement flood protection devices. They are also in interaction with the local actors (elected representatives) and inhabitants concerned by these implementations. From a dialogical point of view, we expect that practitioners integrate the voices of these people in their discourse and representation.

To sum up, this work proposes to apprehend a relatively new technico-scientific concept, Nature Based Solutions, through the Theory of Social Representations. How do experts who do research about NBS or implement them on the field talk about this concept? We think that

their SR of nature and the relation to risk, both influenced by their engineering culture, will frame their discours. This study of their social representations will highlight perceptions, attitudes, as well as obstacles and levers to the implementation of Nature Based Solutions in the field.

Method

1. Participants

Our method of recruitment among French flood risk experts consisted of finding relevant publications for scientists, and positions in professional associations or river syndicates for practitioners. We then contacted the participants by e-mail. 25 potential participants were contacted (12 in the scientists' group and 13 in the practitioners' group) and 19 persons (9 practitioners and 10 theorists) agreed to do the interview. We indicated to those who agreed that their participation was anonymous. The recruitment period ran from April 7, 2021 to October 12, 2021.

The sample was composed of 12 women and 7 men who all have a specific area of expertise with respect to flood risk and were all familiar with NBS. Our categorial variable was profession, with two modalities: theorist or practitioner. The participants' profession, gender and attributed category (theorist vs practitioner) is presented in [Table 1](#).

The interviews lasted an average of 41 minutes and 28 seconds. In all, 13 hours and 8 minutes of recordings were retranscribed in order to be analyzed.

The sample, although small, has satisfied the criterion of redundancy. We made this observation when the new interviews no longer allowed us to create new categories of thematic analysis and when many of the discourses seemed to paraphrase each other.

2. Procedure: Semi-structured interviews

We conducted semi-structured interviews with the participants. The interviews were conducted in French, all the analyses were made on the French verbatim. The elements relevant

Table 1. Participants' description.

Participants	Category	Profession	Gender
P1	practitioner	In charge of aquatic environment management and flood prevention (GEMAPI), flood risk prevention association	F
P2	practitioner	Animator, River Syndicate	M
P3	practitioner	Operation officer, River Syndicate	F
P4	practitioner	Regional coordinator, French Office for Biodiversity (OFB)	M
P5	practitioner	Wetland manager, Geographer	F
P6	practitioner	Works engineer, river syndicate	F
P7	practitioner	Director of development and territorial management, EP Bassin	M
P8	practitioner	Animator, OFB	F
P9	practitioner	Head of the GEMAPI mission	F
T1	theorist	Researcher in urban planning	F
T2	theorist	Researcher in vegetal engineering	M
T3	theorist	Research teacher in civil engineering	M
T4	theorist	Director of a Social and Environmental Psychology research office	F
T5	theorist	Researcher in coastal development	M
T6	theorist	Researcher in hydrogeology	F
T7	theorist	Project manager, OFB	F
T8	theorist	Regional coordinator, OFB	F
T9	theorist	Researcher in environmental sciences	M
T10	theorist	Deputy director, flood risk prevention association	F

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for this paper were translated into English by two of the authors and verified by a professional translator.

The semi-structured interview is defined by Savoie-Zajc [53] as: "a data collection technique that contributes to the development of knowledge favoring qualitative and interpretive approaches pertaining in particular to paradigms. It is a discourse by theme whose order can differ according to the interviewee, whose inference will be moderated and which will contain certain obligatory points of passage." This methodology makes it possible to focus the interview on the specific themes to be addressed but also to give the interviewee freedom of speech to develop his or her discourse.

The interviews were sustained by an interview grid adapted to both field and institutional actors (see [S1 Appendix](#)). This grid goes from the general to the specific and includes questions about the entire creation of an NBS, from its design project to its long-term maintenance following its implementation, as well as obstacles and levers for NBS project implementation. The first question is a question of free association "What do NBS evoke for you?". This type of evocation question is frequently used to describe the content and structure of social representations [54].

3. Data analysis

Two types of analysis were carried out jointly: a thematic analysis and a lexicometric analysis. Thematic analysis [55] consists of reading the interviewee's discourse carefully and then in cutting up and grouping the speaker's interests, i.e., recurrent speech, into categories. This discursive examination of the aspects addressed makes it possible to classify them into themes and sub-themes. In brief, it is a matter of gradually answering the general question: "What is fundamental in this speech?" [56]. We found 14 categories and 50 sub-categories (attached in [S2 Appendix](#)). The thematic analysis, in the same way as content analysis, brings out the opinions and attitudes [57].

Lexicometric analysis was conducted on the entire corpus of interviews using the Iramuteq software [58]. Iramuteq is an open-source software package used to perform statistical analyses—like similarity analysis—on text corpora. This allowed us to highlight quantitative results in terms of frequency by analyzing similarities. This similarity analysis is based on the idea of association [59]. It uses the Chi2 index to calculate the co-occurrence of verbatims, in other words, the number of times elements appear at the same time in the discourse. It is based on graph theory and highlights the common and differentiated elements of a textual corpus according to different variables [59]. By discerning thus central and peripheral elements, we could apprehend the structure of the social representation [60].

Results: From common ground to disparities

We will present the lexicometric analysis and the thematic analysis at the same time complemented by citations from the verbatim. These combined analyses allow to frame the experts' SR by other SRs such as nature, risk and engineering culture.

1. Common basis of representation

The similarity analysis [59], highlights the common aspects and differences between the two groups of experts: theorists and practitioners. In [Fig 1](#), the thicker the lines, the more often the words were associated or used together. In black are all the elements both types of participants used interchangeably (their "common representation"), in blue all the elements that were significantly more often used by theorists than by practitioners, and the contrary for elements in

management such as the locations “area”, “river” “basin”, the tools of management “planning” “GEMAPI”, the partners “collectivity” and the possible aims “renaturation”, “vegetation”, “natural”. Many terms are also shared with regard to NBS, related notably to “project”, its “complex” nature and possible “barriers” around the stake to “protect” “stakeholders”. This “scientific” “concept” is also clearly linked to “climate change”. Its two main definitional dimensions are mentioned by both groups: to be at the same of service to society (“solution” “flood” “risk” “protection”) and to “nature” (“biodiversity” “ecological”, “environment”).

Still concerning “water”, the practitioners talk more often about very concrete aspects “field”, “funding”, as well as institutions, “syndicat”, and people, “owners”. This same attention to people and specific places is visible in practitioners discours about “territory”, “dyke”, “local” “population”, “policy” “inhabitants”, “farmer”, “embankment” and “vegetal” when discussing NBS. Here again, theorist have a more global view, associating specifically “ecosystem”, “co-benefits”, structure” and “engineering” to NBS.

Thus, despite common elements, there are also differences that distinguish the social representations of Nature Based Solutions of theorists and practitioners.

2. What distinguishes practitioners and theorists

The thematic analysis reveals that the gap between the concept and its implementation on the field is related, according to interviewees, to the perception of the IUCN definition. Five experts, both theoreticians and practitioners, describe this definition as broad and vague: “it’s vast, in fact, it’s vast” (GEMAPI project manager, river syndicat); “from the moment you are going to say a use of something natural, I would say that you can qualify it as an NBS?” (researcher in hydrogeology). Two of them went so far as to describe the concept as difficult to apply: “the municipalities that really do what the IUCN definition says, there aren’t that many [...] if we want to apply the whole IUCN definition to the letter, it becomes complicated to really find what fits in [...] it’s quite restrictive” (director of a flood risk association); “It’s hard to grasp the concept, to apply it in an operational way” (EP basin manager). For these interviewees, the concept is too new and has too many implications to be easily adopted and translated on the field. Others are waiting for NBS to prove themselves: the lack of evidence by example is mentioned by four experts: “I am waiting for concrete operations of nature based solutions” (GEMAPI Mission Officer); “what is needed now is feedback” (researcher in environmental sciences). Interestingly NBS techniques are portrayed as “old” by nine experts (both practitioners and theorists) who detail NBS as “rustic” or “rudimentary” solutions (or similar terms) and have been used, according to them, in the field for decades. The experts seemed to differentiate between the recent concept promoted by international institutions and the long-proven techniques it contains. According to experts, decision-makers appreciated this concept, but this was not necessarily the case for local people: “I think that some decision-makers like this concept, but the residents have a hard time understanding and accepting it” (wetland manager). This is an example of the dialogical nature of SR [26] where experts take into account in their discourse how other social groups consider NBS.

The perceived opposition of the inhabitants as well as their “preconceptions” were cited by six experts: “a rather strong opposition of these farmers [...] it was really a psychological barrier for the farmers who were really against it and took a hostile stand against the principle” (in charge of GEMAPI, river syndicate); “the major oppositions in the territory between the inhabitants and the managers of the natural environment” (in charge of operation, river syndicate); “this concept generates a lot of conflict [...] there are quite a lot of protests (in charge of a wetland). These aspects seem opposed to the desire to involve the inhabitants in the projects and seem contradictory to the “participative” lever developed by IUCN. Moreover, three experts

stated that it was impossible to calm conflicts and that they were obliged to expropriate: "In the long run, it will be done, but it will be painful" (works engineer, river union); "The only solution for the moment is to expropriate" (facilitator, OFB); "once the project is declared to be of public interest, that is what justifies the right to expropriate" (works engineer, river union). This way of proceeding is the antithesis of the community participation strongly encouraged by the institutions that support the NBS concept. This discrepancy reflects difficulties in articulating this participatory concept, which is not easy to implement [61] and requires scientific rigor [62]. Conflict around NBS emerges not only between inhabitants and institutions, but also between experts or institutions, as six experts mentioned: "I don't think they [the scientists] tell you [the interviewer] the same thing because they work for nature, that's their primary objective" (operation manager, river syndicate about environmental researchers); "they [the elected officials] don't trust each other [. . .], they don't trust each other between elected officials, in fact they have the impression that they won't be the ones to decide" (coordinator, river syndicate).

The term "NBS" was significantly more often used by theorists during the interview (Fig 1). NBS would therefore be a rather conceptual term that is less used in the field. This result is in line with our thematic analysis in which seven participants describe the term NBS as conceptual and scientific, which is not present in the field: "I find that there is really a distinction between the organizations that drive this concept [. . .] and the local level, which is a little out of step and needs to be informed and understand what is being proposed with this concept of NBS " (GEMAPI officer, association); "the people who are more in the field do not communicate at all on this subject" (wetland manager). Moreover, six participants of both groups added that when talking about NBS, their discourse must be adapted according to the interlocutor, and that this term is not appropriate for all audiences: "depending on the profession, we do not call things by the same name" (researcher in hydrology). In the SR of the interviewees, the term NBS is not unifying and not necessarily understandable for all stakeholders, particularly those in the field.

The similarity analysis highlights (Fig 1) also that the term "dike" is used primarily by practitioners. This strong reference and attachment to this type of grey solution seems an element galvanizing a gap between theorists and practitioners, between concept and field. In fact, the institutions and scientists who support the NBS concept, such as the IUCN or the OFB, propose a sort of alternative to grey solutions. Without pitting grey solutions against nature-based ones, dikes as such do not form a part of NBS. However, the practitioners frequently mentioned dikes in their speeches, explaining that France could not do without this type of engineering: "Today, cities like Arles or Avignon would not exist without dikes" (works engineer, river union). Indeed, five actors, both practitioners and theoreticians, defined NBS as complementary to the so-called grey solutions: "we are not going to think of a total substitution but of a link between these two practices" (researcher in urban planning).

Finally, we note that most of the terms related to the field appear more often in the practitioners' speech such as "territory", "farmers", "inhabitant", "population" and "local". These terms were very frequent in the speech of the practitioners and concerned a large part of their discourse. For them, the inhabitants and local population in general represent as much the people to be protected from the risk, as the individuals who need to be convinced for NBS projects to see the light of day. In the practitioners' view, inhabitants represent actors to be involved directly in the NBS projects: "For me, the inhabitants should participate [in monitoring the works]" (OFB regional facilitator); "NBS [. . .] imply much greater participation from local populations" (Environmental science researcher). In addition, the words "funding," "policy," and "landowner" highlight problems encountered in field implementations of NBS projects such as lack of funding, difficulties related to local policy decisions that do not favor NBS,

or the refusal of landowners to give up their land. In fact, many of the NBS projects cited by the experts involve land negotiations with local farmers. Close to the previous words on the similarity chart, the term "complicated" was also used by the practitioners. It describes the complications of implementing NBS projects on the ground, but also the fact that it is complicated for non-specialized inhabitants and actors to understand and accept the term NBS as sustained by the verbatim comments.

To sum up, we can see through the lexicometric analysis that both groups have many terms in common especially related to water management and the major dimensions of NBS (protection against risks and biodiversity). They also have some particularities with the practitioners seeming to relate more to places and people (with whom they have to interact in order to implement NBS) and the theorists envisaging NBS in a more ecosystemic approach.

The results of the thematic analysis allow contextualising the lexicometric analysis and deepening qualitative aspects notably regarding the representational context of representations of nature and risk, and the role played by engineering culture.

The thematic analysis highlighted several major themes that can be broken down into several sub-themes. As we were particularly interested in the implementation of NBS, we were especially attentive to the theme of barriers or leverage interviewees talked about. This focus also allows to sustain the socio-dynamic and dialogical approach to SR, as these arguments are always a positioning of the interviewee regarding the alter (the inhabitants, the institutions) and the object (the NBS).

Discussion

In this part, we propose to discuss the results by analyzing their relation to the engineering culture, as well as related social representations concerning risk and nature.

1. Engineering culture

The first barrier echoes the persistence of an engineering culture favorable to grey infrastructure [47, 48, 63–65] that would leave no room for NBS projects. Three experts spoke of a "cultural bias" among residents used to protection from flooding through engineering projects. A researcher in environmental science delivered the following discourse: "there is a cultural bias that makes people feel protected behind a civil engineering work" "the impression of protection". Furthermore, a project manager from the OFB stated that "when we build a dike, we feel protected and therefore we increase vulnerability by building schools and hospitals behind the dike". For her, this cultural bias would indirectly lead to increased vulnerability. Indeed, the construction of a levee can sometimes increase vulnerability by amplifying the number of vulnerable buildings in a flood zone [66] or by increasing the speed and rise in the water level near the levees in the event of a breach or overflow [67]. Parker [68] and Sauri-Pujol [69] even spoke of an "escalator effect": in addition to the technological risk caused by the potential failure of a dike, the latter unduly authorizes urbanization behind it which proves to be an essential risk factor. Here, the impression of protection reduces risk culture and increases vulnerability. On the other hand, a person in charge of operations in a river syndicate expressed that "there is even a somewhat general demand from the population to say reinforce everything, raise everything, they want more protection". In addition, two other participants mentioned old and ineffective dikes: "we have dikes that are unreliable" (works engineer, river union) and "they are collapsing, they are completely dead" (leader, river union). Despite this, a firm demand from the population was described by experts, a demand to keep these dikes that no longer protected them in their current state. Experts attribute to the population a lack of risk culture.

2. The risk culture

In the eyes of the experts, the second obstacle for the implementation of NBS is the lack of risk culture and awareness in the local population. This was mentioned by nine participants: "Elected officials are also like the locals, they are not very sensitive if they have not experienced a recent flood", "knowledge of the risk, there is not much of it" (facilitator, river union); "every time we ask ourselves: how is it possible to have built in that place? "; "I don't think we are aware of this" (OFB project leader); "they [the communities] need to be informed about this" (GEMAPI officer, association). This lack of risk awareness seems to be accompanied by a lack of knowledge of NBS that can lead to their rejection: "some cities, regarding development projects, refused to accept ditches or other solutions because they did not know what they were, they did not know how to manage them" (Civil engineering researcher); "we realized that the actors interviewed were not necessarily aware of the concept" (Manager, EP basin). These actors all agreed on the fact that the culture both on flood risk and on NBS would be essential: "The municipality must take charge of it and work on training agents, and also work to get agents to accept this kind of differentiated nature" (Director, research office). In addition, two participants believed that awareness of NBS can lead to an acculturation of flood risk: "NBS to maintain a flood subsidence culture that was favorable to wetland species but which also allowed riparian populations to maintain their traditional flood subsidence culture that had been removed with the dam" (project manager, OFB); "it is still a term that allows for a better acculturation of both elected officials and citizens" (regional animator, OFB).

These first two obstacles put forward by interviewees highlight the fact that in certain cases civil engineering structures can increase vulnerability and do not help to improve risk culture. On the other hand, they help to reassure residents through the fact these structures make human beings feel as if they can control floods and therefore risk.

3. Relation with nature and ecosystems

The third and final obstacle concerns the need to control the ecosystem. A researcher in coastal development evoked "a culture of control and domination of natural spaces". Also, the director of an engineering firm described "the need to control" nature. These anthropocentric beliefs unite in a libertarian conception of society ensuring that each individual has the right to do, especially with regard to nature, what they feel contributes most to their well-being [51]. Conversely, NBS propose a conception where humans would no longer be in control of their ecosystem and would no longer be in total control of the risks: "when we implement NBS we are not in control of the globality of the system we are touching, but rather we will try to guide a system by developing an environment, hoping that a biocenosis will develop there" (researcher in urban planning). The same researcher describes a "principled opposition to change the way we think" while the OFB project leader suggested a "paradigm shift". All of these elements can be related to the New Environmental Paradigm [40] which summarizes a worldview where humans respect the environment more. This new worldview is based on five beliefs: the existence of ecological limits to growth, the importance of preserving ecological balance, the rejection of anthropocentrism, the rejection of human exemptionalism, and the existence of an ecocrisis. All these citations show that in our sample several representations with regard to nature and environment exist. Many participants explained that "making more room for nature" was a key element in understanding NBS and the benefit it could bring to the field of risk management and society. Indeed, six participants, both theorists and practitioners, linked a broader conception of nature to the concept of NBS. We can summarize this thinking in the following words: NBS thinking would be to leave more room for nature. Some experts express it directly in this way: "the idea is to let the sea in more" (researcher in SDL'E); "to give more

space to water" (in charge of GEMAPI, an association); "to give space back to nature, to accept that the sea comes in" (researcher in coastal development). According to these experts, NBS are conceived and designed to leave more room for natural ecosystems. In putting forward this point, they embrace a more balanced attitude towards nature, contrasted to the traditional engineering culture. However, more precisely, this implies knowing how to incorporate one's needs into natural processes [70] and accepting to live with the hazard without trying to oppose it, leading to a form of diminished control. Indeed, one expert explained this concept by speaking of "we will give 300 hectares of land to the river and to nature" (works engineer, river union). According to interviewees, this need for control would be put into question through NBS, forcing people to leave more room for risk, physically and cognitively, and thus live with risk. Moreover, the urban planning researcher spoke of this conception in the following terms: "instead of considering a river as a flow, we will consider it as a moving fluid loaded with particles that has its own life". These words echo Descola's work on nature conservation. The latter explained that for him, it is no longer a question of considering nature as a useful common good but of protecting it "in and for itself" [71]. Thus, an expert added: "If you have more vegetation near your home, you will have more insects [. . .]. Afterwards, is it serious? I think it's part of this whole awareness and acculturation process that has to do with the relationship that humans have with nature" (regional facilitator, OFB). According to participants, NBS could also be a tool for acculturation to the fauna and flora by creating proximity.

4. Limits of our study

Our first limitation concerns the type of analysis that we choose. We are aware that this corpus could give rise to other analyses, such as structural analyses. We believe that both similarity and thematic analysis are of interest, and that future work exploring in greater depth the central elements of NBS SRs would be of great interest.

The second limitation is an aspect of pure feasibility: we conducted these interviews by videoconference as most were done during a period of lockdown in France, related to the COVID19 pandemic. For the sake of consistency, all the interviews were conducted by videoconference, under the same conditions. Even if, using a camera, interaction can be comparable with the presence of nonverbal and social cues [72], interviews in real-life conditions would certainly have yielded richer results and a picture still closer to the field.

Another limiting aspect concerns the discourses of the inhabitants, which are reported by theactors who have worked with the inhabitants affected by the NBS they were implementing. These inhabitants are not directly represented in our study. We had to make this choice following a pre-test of our interview grid with some residents which showed that the term NBS was not adapted to address this type of population. The results of this pre-test were then confirmed by our study. We are at present conducting a study focused on inhabitants in order to address this limitation. Finally, as our study is limited to the French context, it would be interesting to study the social representations of NBS by experts from other countries, to establish whether there are similarities or disparities.

Conclusion

In this article, we focused on experts' social representations of Nature Based Solutions for flood risks. To do so, we interviewed 19 experts on flood risks and NBS. We analyzed their discourses using two methods: thematic and lexicometric. Results showed that this concept suffers from a significant gap between the principles it embodies and the reality on the ground, as reported by experts.

In terms of social representations, the results show that the concept of NBS, as described to us in the interviews, has not yet gone beyond the scientific sphere, nor has it become

embedded in a common language. The experts themselves have different visions of the NBS object. NBS will therefore likely still have to go through this process of being extracted from the theoretical jargon and acquiring meaning in the eyes of a larger number of individuals and specifically non-specialists such as inhabitants and elected officials.

The SR that experts have of the NBS object has a central structure shared by theorists and practitioners, and then several dimensions specific to each group. Their SRs are framed by SR on nature and the question of mastery of risks. The persistence of a culture favorable to grey infrastructure and the need to control the ecosystem are a matter of habit. In France, civil engineering structures are traditionally used to protect against flooding, and the arrival of NBS could be resented as a threat to this tradition. The lack of risk culture reported by the interviewees is a direct consequence of the two previous elements. Indeed, according to them, by no longer considering the flood risk as part of their environment or daily life, inhabitants will never be ready to adopt the appropriate behaviors or to take material provisions to mitigate the risk. In their discourse, experts question this habit of reliance on civil engineering that has led to the need to control the ecosystem and the risk.

We can say that the interviewees situated NBS in a more encompassing discourse and in relation to different, much larger social sets such as nature and climate change. Once again, social representations serve as a guide to understanding and mastering our daily environment, since they constitute a "contextualizing" rationale [73].

To reconnect practice and theory, it can be interesting to use vocabulary which refers to ancient techniques well used in the field. Social psychology of the environment can propose, through the TSR approach a way to better understand social thought and common knowledge. This might be useful for promoting the appropriation of the concept by the actors in the field. However, the term "Nature Based Solution" does not seem appropriate and does not manage yet to go beyond the scientific sphere [30]. The considerable polysemy of the term nature and the vague and broad aspect of its definition add to this gap. Thus, we consider that this term might be inadequate for communicating with all the actors, especially non-specialists such as inhabitants. Even experts seem to differentiate the concept from the techniques it contains. It is necessary, at present, to imagine a more appropriate common language that will allow everyone to know the stakes of NBS and the benefits they can contribute in terms of biodiversity and flood risk protection. We propose to use "vegetal engineering" to enhance the value of rustic and ancestral knowledge, linking it directly to the techniques employed by practitioners, and raise public awareness rather than considering them as new avanguardist techniques.

The perspective of "leaving more room for nature" indicates that the concept of NBS could be framed by the New Environmental Paradigm (NEP) worldview [40]. We even think that NBS could foster a pro-environmental attitude thanks to the acculturation they allow. Our task today is to understand the link between the rationale of NEP and the NBS concept. In the next part of our work, we will explore this link: Could a strong NEP attitude go hand in hand with an acceptance of NBS? To what extent could NBS foster a pro-environmental attitude through the acculturation they allow?

Supporting information

S1 Appendix. Interview guide.

(DOCX)

S2 Appendix. Thematic analysis.

(XLSX)

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