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Assessing Perception of Climate Change by Representatives of Public Authorities and Designing Coastal Climate Services: Lessons Learnt From French Polynesia

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Institutional actors have a crucial role in adaptation to climate change, especially for highly vulnerable territories such as small tropical islands. Here, we emphasize their major role in the co-design of tailored coastal climate services (CCS) based on a case study of French Polynesia. In this perspective, we assessed climate change perceptions by public authorities and identified their needs with regard to climate-related science. This assessment included an analysis of the decision-making context, semi-structured interviews with practitioners representing 23 administrative divisions directly or indirectly involved in climate change issues, and a workshop dedicated to discussing needs in terms of CCS. Generally, respondents did not identify climate change as a major current issue in French Polynesia; they showed more concern for economic growth, pollution, land tenure, and land use planning. However, interviewees were concerned about future impacts of sea-level rise (SLR) and ocean warming and acidification, mentioning in particular their detrimental impacts on marine ecosystems, shoreline position, economy (especially agriculture and the blue economy), and freshwater resources. The interviewed practitioners showed particular interest in SLR projections for future decades up to a century, and for knowledge on expected impacts to critical infrastructure, coastal systems, and natural resources. Practitioners' needs made it possible to co-define four CCS to be developed: (1) the design of sea-level-rise-compatible critical infrastructures (airports and ports); (2) adapting to the risk of destabilization of beaches and reef islands; (3) professional training on climate change impacts and adaptation, including an analysis of potentially emerging new jobs in the SLR context; and (4) the development of participatory approaches for observing climate change impacts. While the co-development of these CCS will require a multi-year engagement of stakeholders concerned with climate change adaptation, our results already shed light on specific needs for salient CCS in highly vulnerable tropical island territories.

Keywords: adaptation to climate change, climate change perception, climate governance, coastal climate services, French Polynesia

INTRODUCTION

Small tropical islands are recognized as being at the forefront of climate change (CC) impacts, although they are not the principal emitters of greenhouse gases (Sinivasan, 2010). Because of their biophysical characteristics (limited terrestrial surface area, high exposure to storm-related events, important role of the reef ecosystem as a sedimentary source and as a wave buffer; Duvat et al., 2016), they are highly exposed to SLR and to the intensification of storm waves that increase the risk of coastal erosion, marine flooding, and salinization of soils and aquifers, in addition to ocean heating and acidification which carries a high risk to the decline of ecosystems (Gattuso et al., 2015; Perry et al., 2018; Scandurra et al., 2018). And even more so because future impacts of climate change will be greater than current impacts (Nicholls and Cazenave, 2010; Church et al., 2013; Oppenheimer et al., 2019). Socioeconomic characteristics of small tropical islands, notably the Small Island Developing States, also contribute to their vulnerability (Duvat et al., 2017; Scandurra et al., 2018): the high density and rapid population increase of some islands, the scale of economic activities and subsistence depending on the climate and environment (Kuruppu and Willie, 2015; Pondorfer, 2019), the limited nature of terrestrial natural resources, in addition to human, technical, and financial capacities that are limited compared to those of continental countries (Nunn, 2009). Moreover, the fact that these are States or territories with recent political constitutions (recently formed) and a history of colonization, of which some remain contested (e.g., land tenure), contributes to their vulnerability. For these different reasons, the small tropical islands are among the most exposed and the most vulnerable to the impacts of climate change (Nurse et al., 2014).

Small tropical islands' high vulnerability to climate change impacts make it urgent to implement a process of adaptation to climate change (Kelman and West, 2009; Barnett and O'Neill, 2011) and especially policies of adaptation to climate change. These policies must be specific to each territory because the vulnerability of each small tropical island is itself specific, due to its physical, social, political, cultural, and other factors (Tompkins et al., 2010; Nunn et al., 2014). The goal of climate change adaptation policies is to maintain the viability of these territories (Keener, 2013) which, in the case of atolls, in a context of SLR, is threatened by increasing frequency of marine flooding (Beetham et al., 2017; Storlazzi et al., 2018). These adaptation policies must be carried out by public authorities. In our paper, we identify institutional actor as an individual involved in decision-making and the implementation of public policies, and therefore include decision-makers and practitioners. Their decisions are, like those of individuals, influenced by several factors. Although we do not study institutional actors as individuals, we acknowledge they carry 'personal baggage' that affects perceptions of climate change. Therefore, decisions may be influenced by personal factors related to gender, age, values, beliefs, experience, training, social rank, ethnicity, and personality, as well as wider factors such as social environment, media influence, and economic system (Montreux and Barnett, 2009; Deressa et al., 2011; Goeldner-Gianella et al., 2019). The

more they consider climate change as distant, whether spatial or temporal, the less they feel concerned by its impacts and the less they accept and support policies of adaptation to climate change. Generally speaking, the knowledge of an individual about a given issue affects perceptions and actions with respect to this issue (Singh et al., 2017). According to the authors, individuals are conscious that climate change will have major consequences in their territory in the future, but they generally think they will not be affected in the short term. Secondly, decisions made by institutional actors are affected by the perceptions, necessarily subjective (Beyerl et al., 2018), that they have of the problems and questions they deal with on a daily basis within the framework of their work. In third and fourth places, the decisions they make are affected, on one hand, by the perception they have of the situation of their territory, and on the other by their perception of climate change and its impacts on this territory (Frondel et al., 2017). As a result, the institutional actor's knowledge and understanding of climate change, while acting as an individual and going about assigned tasks, will affect their perception of climate risk and, as a result, the manner in which tasks are understood and fulfilled within the domain of climate change adaptation.

With regard to these elements, it is important that these institutional actors have access to scientific knowledge to understand climate change and its impacts and thus to be in a position to plan and implement measures to better adapt to climate change (Lata and Nunn, 2012). Even so, there remains a gap between data produced by various areas of science and the needs of institutional actors (Hewitt et al., 2012). For small tropical islands, this can be illustrated by the few scientific studies related to risks connected to SLR and cyclone impacts (Willis and Church, 2012; Brown et al., 2013) or by scientific data formats unsuited to the needs of institutional actors (Brasseur and Gallardo, 2016). For the establishment of effective projects for adaptation to climate change (e.g., laws and regulations, field actions) it is necessary for institutional actors to understand the specific current and future impacts of climate change on their territory, which in turn necessitates adequate and technically accessible scientific information (Webber, 2017). It is the goal of climate services to reduce the gap between science and action (Vaughan et al., 2016). More concretely, it is a question of providing to users, including institutional actors, scientific information related to past, present and future climates that may be pertinent and suitable for their needs, and thus useful, and directly usable for the goal of aiding their decision-making (World Meteorological Organization [WMO], 2011; Le Cozannet et al., 2017; Damm et al., 2019). The users formulate the crucial needs for scientific knowledge to implement their projects and/or decision-making, needs that are satisfied by the scientific community, which supplies pertinent climate data and formulates answers to problems raised by the actors.

According to Ishaya and Abaje (2008), most studies on climate change perception have been conducted in developed countries in the northern hemisphere. Moreover, Lee et al. (2015) highlight that "current research on public perceptions of climate change has been dominated by studies in Australia, the United States and Europe." Thus, our study contributes to enriching our knowledge of climate change perception among institutional actors of an

island territory in the southern hemisphere, and more precisely the Pacific. This article presents the results of a methodological protocol that was used in French Polynesia to co-construct coastal climate services (CCS) with institutional actors. This protocol, which includes an analysis of the governance context of this territory, semi-structured interviews with practitioners, and a workshop, was set up for the purpose of defining CCS that support the adaptation of this territory to SLR. This approach is part of a multi-disciplinary and iterative approach to develop CCS based on principles of co-conception and co-development (Gibbons et al., 1994; Lang et al., 2012), including their societal, economic, scientific, and educational dimensions (Chambwera et al., 2014). The goal of this article is to respond to the following question: “How to co-develop CCS for adaptation to SLR with institutional actors of a given territory.”

We present the territorial context and methods used, then the results of the perception study that was developed with institutional actors, and the identified CCS.

CONTEXT OF STUDY

Study Area

French Polynesia is a French overseas territory located in the South Pacific between 10 and 30°S latitude and between 133 and 155°W longitude. It comprises five archipelagos, the Marquesas Islands, the Tuamotu Islands, the Gambier Islands, the Society Islands, and the Austral Islands (**Figure 1**). The most recent census (2017) counted 281,674 inhabitants, 87.7% of which live in the Society archipelago (Institut de la Statistique de la Polynésie française [ISPF], 2017). In 2017, the GDP of French Polynesia increased to 5.04 billion € an increase compared to the preceding year (4.91 billion €). The service sector occupies a major position in the economy, with a rate of 8 out of 10 salaried people (Institut d'Emission d'Outre-Mer [IEOM], 2018) with more than 52,000 salaried people representing 82% of salaried persons, compared to 15% in the manufacturing sector and 3% for the primary (agriculture, fishing) sector (Institut d'Emission d'Outre-Mer [IEOM], 2018). Tourism (17% of the GDP; Institut d'Emission d'Outre-Mer [IEOM], 2018), pearl farming (63% of export revenue in 2018), fishing (11.5% of export revenue in 2018) and agriculture are the principal economic resources of this overseas territory (Institut d'Emission d'Outre-Mer [IEOM], 2018).

French Polynesia has held autonomous status since 2004, defined by Article 74 of the Constitution (Organic Law No. 2004-192 of 27 February 2004, concerning the autonomy statute of French Polynesia) which establishes governance shared by the Country, represented by the institutions of French Polynesia, and the French State, represented on site by the High Commission, directed by the High Commissioner. The High Commissioner oversees the coherence of activities conducted by locally present services of the French State. His principal mission is to ensure that laws are respected and to exercise oversight of the legality of the proceedings of the community. Nationality, civic, civil and electoral rights, justice, foreign policy, defense, entry and visitation period of foreigners, safety, public order, treasury, police, surveillance of maritime fishing, rules relative

to administration, audiovisual communication, higher education or research fall within the jurisdiction of the authorities of the French State. French Polynesia has four institutions: President of the government, the government, Assembly (which votes on laws) and the Economic, Social, and Cultural Council. The services of the Country are distributed between the President and the ministries that make up local government. The 2004 organic law mentions that all jurisdictions not attributed to the State (article 14 of the 2004 organic law) and to the municipalities revert to the Country. Thus, in this overseas community, the institutional and decisional landscape is composed of State services and Country services (**Figure 2**).

State services are overseen by the High Commissioner and those of the Country are under the supervision of members of local government, namely the President and his ministers.

Materials and Methods

The methodological protocol that was developed includes three principal and complementary stages: an analysis of governance done for the purpose of identifying institutional actors involved in the subject of climate change; the administration of semi-structured interviews with these actors; and the organization of participatory workshops seeking to identify CCS to develop for adaptation to SLR.

Identification of Concerned Institutional Actors

As discussed previously, French Polynesia has an autonomy statute that permits the transfer of numerous jurisdictions from the State to the Territory (**Table 1**). These jurisdictions can be distributed among the services of various ministries and are described in various official (bills) and informational (e.g., annual report of the Overseas Issuing Institute, documentation of the Statistical Institute of French Polynesia, scientific article) documents, which were consulted.

The distribution of jurisdictions between State and Territory, illustrated in **Table 2** for the two domains of development and construction, on one hand, and the environment and biodiversity on the other, shows complex governance (**Table 2**). For example, the Department of Public Engineering (DPE), which is a service of the State, can be asked to provide engineering for the Territory, although the Territory has a dedicated service, the Department of Construction (DC). Another example that illustrates governance complexity is the organization of activities to undertake during and after an exceptional event such as a tropical cyclone. Protection of property and persons remains within the jurisdiction of the State. The High Commissioner must activate the ORSEC plan (emergency organization) with the participation of State services (army, police) and the mayors involved (municipal police and firemen). The armed forces of French Polynesia, in liaison with the High Commission, ensure among others, emergency missions to populations. Even so, the DC, a service of the Territory, also has as its mission “the assistance to populations threatened or affected by events calling for the emergency delivery of persons, material, supplies, provisions, and commodities of all types useful for the preservation or the re-establishment of normal living

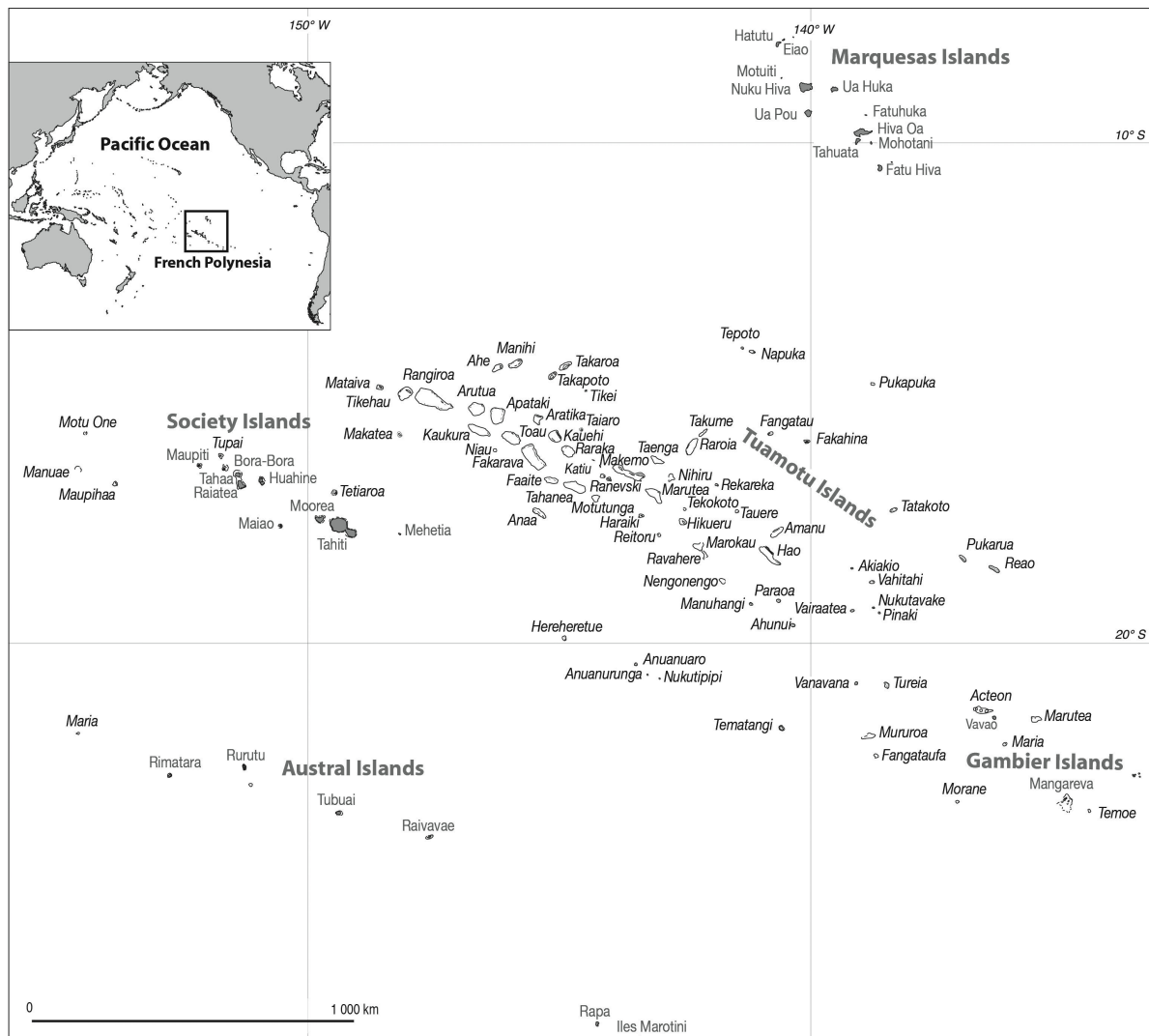


FIGURE 1 | Map of French Polynesia.

conditions.” Thus, although protection of the population is the responsibility of the State, the Territory can provide support to populations through the DC.

In this context of complex governance, it is not easy to determine if a service has jurisdiction and/or missions related to climate change. In fact, the term “climate change” is rarely used in the description of the jurisdictions of the services and divisions of the Territory and the State. In this study, a service was considered to be involved with climate change if its jurisdictions and assignments consider, at a minimum, one of the following four criteria:

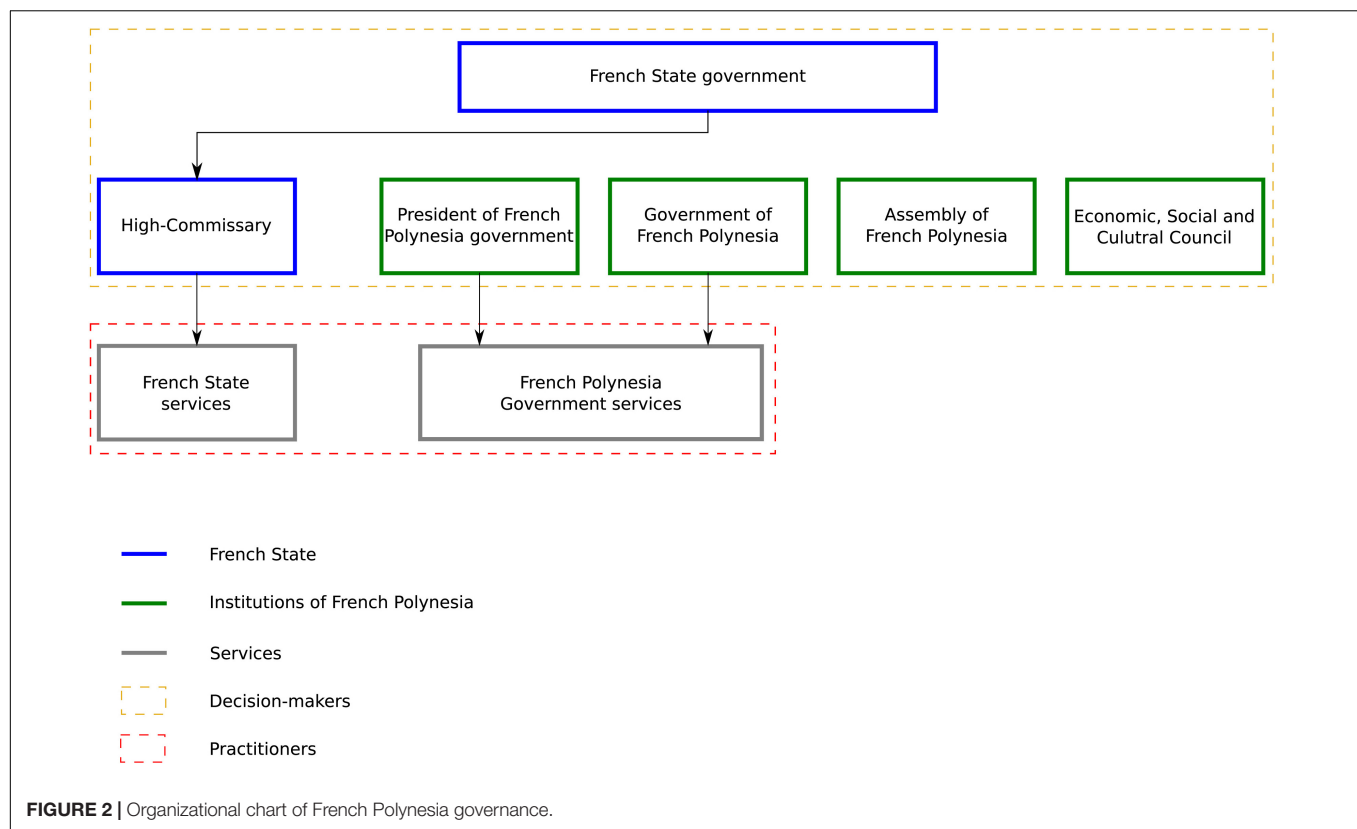
1. The service is dedicated to a climate-dependent activity;
2. The service is dedicated to an issue that could be impacted by climate change;
3. The service includes emergency services in the event of a natural disaster;

4. The service is in charge of studies or research related to climate or environment (physical or biological).

Perception of Climate Change by Institutional Actors in French Polynesia

Based on preliminary identification of climate change services in French Polynesia, semi-structured interviews were conducted with their representatives, following an interview guide whose rubrics and questions are presented in **Table 3**. The two objectives of these interviews were to determine the institutional actors’ perception of climate change and their needs in terms of scientific knowledge. This interview guide addresses five principal themes, approached through eleven open questions. The five themes that were raised, ordered from general to particular, are the following:

1. Climate change in French Polynesia.
2. SLR in French Polynesia.



3. Actions and projects implemented and in the process of implementation to adapt to climate change, and the barriers to carrying out these projects in French Polynesia.

4. Needs for scientific understanding on climate change and SLR.
5. Involvement at regional level in adaptation to climate change

TABLE 1 | Documents used to identify services involved in climate change in French Polynesia.

Source	Information
Organic Law No. 2004-192 of 27 February 2004	Autonomy Statute of French Polynesia <ul style="list-style-type: none"> – Distribution of jurisdictions between the State, the Territory and the municipalities of French Polynesia – Institutions of French Polynesia – Role and activities of the State and the High Commissioner of the Republic in French Polynesia
Official Journal of French Polynesia http://lexpol.cloud.PF/	<ul style="list-style-type: none"> – Components of the Territory – Description of ministries and their actions – Description of ministerial services
Official site of the High Commission of the Republic in French Polynesia http://www.polynesie-francaise.pref.gouv.fr/	<ul style="list-style-type: none"> – Description of State services – Description of the services of the High Commission
Moyrand A, 2013. Introduction to the study of political and administrative institutions of French Polynesia	<ul style="list-style-type: none"> – Institutions of French Polynesia and distribution of power among them – Powers of the State in French Polynesia

To provide consistency, a single interviewer conducted all interviews. The interviewer strove to maintain the order and designation of the questions in all interviews. The interviews were recorded, with the agreement of participants. This process allowed the interviewer to listen well and favored a fluid exchange. In the treatment phase, the fact that interviews were recorded made it possible to do a faithful re-transcription of the responses given and build a list of responses. This list enabled quantitative (rate of response occurrence, after regrouping) and qualitative (re-transcription of speech) analysis of the climate change perception of the institutional actors involved. The choice of this methodology was inspired by previously conducted environmental change perception studies and was based on the meetings with various types of participants, such as residents, managers or community leaders (Beyerl et al., 2018; Lemahieu et al., 2018; Martin et al., 2018; Stancioff et al., 2018; Wetende et al., 2018; Cuthbertson et al., 2019).

Workshop Organization

Following the interviews conducted with the institutional actors, a workshop was held in Tahiti on March 22-23, 2018, to define CCS to be developed. The workshop pulled together the identified institutional actors, representatives of environmental protection associations, representatives of research institutes based in French Polynesia, and project scientists. The workshop included scientific presentations, a round table, and focus groups.

TABLE 2 | Examples of jurisdiction sharing between State and Territory.

Domain	Entity	Service	Principal jurisdiction
Development and construction	State	Department of Public Engineering	<ul style="list-style-type: none"> – Engineering services for the State, French Polynesia, or public establishments – Technical assistance to municipalities and administrative divisions of the State
	Territory	Department of Construction	<ul style="list-style-type: none"> – Monitoring, management, conservation, maintenance of terrestrial, fluvial, and maritime public domain of the territory and related engineering works.
Environment and biodiversity	State	French Agency for Biodiversity	<ul style="list-style-type: none"> – Support for the implementation of public policies in the domains of knowledge, preservation, management, and restoration of biodiversity of terrestrial, aquatic, and marine environments – Technical support for the Government of French Polynesia related to the creation and management of protected marine areas
	Territory	Department of the Environment	<ul style="list-style-type: none"> – Implementation of the policy of prevention, reduction, or suppression of pollution and nuisances related to economic and human activities – Monitoring, preservation, and protection of habitats of fauna and flora – Conservation and development of natural protected spaces

TABLE 3 | Questions asked and objectives of the semi-structured interview guide.

Theme	Question asked	Objectives
1	In your opinion, what are the three major issues facing French Polynesia now + in 2050 + in 2100?	Find out if climate change is identified as a major issue in French Polynesia, and at which timescales
	In your opinion, which climate change effects will significantly affect French Polynesia?	Find out if sea-level rise is a current concern
	In your opinion, what climate change impacts do you expect in French Polynesia in the future?	Find out what climate change impacts (including sea level rise) are of concern for actors
2	In your opinion, is sea-level rise already an issue in French Polynesia? If it isn't, will it become a major issue in the future? In 2050, 2070, 2100?	Determine their perception of SLR
	What are the main problems that SLR may cause in French Polynesia? In your opinion, what might be solutions to employ against sea-level rise?	
	According to you, what territories/islands/areas are the most threatened in French Polynesia?	Find out about their perception of the highly-threatened areas
3	Does your service lead/participate in adaptation to climate change actions? Which ones?	Take stock of adaptation to climate change actions, including the consideration of sea-level rise and scientific research in these actions
	Do you face difficulties carrying out adaptation to climate change action in which you are involved? If yes, what kind of problem?	Identify barriers to adaptation to climate change, and determine if the lack of knowledge/access to knowledge is a barrier
4	Do you have needs in regard to climate change, especially sea-level rise?	Identify actors' needs in scientific data on sea-level rise impacts
5	Are you involved in regional adaptation to climate change programs/actions?	Identify regional adaptation to climate change programs in which French Polynesia is involved

This workshop with institutional actors made it possible to better identify the need for scientific information and to co-define climate services to develop to respond to their needs for adapting to sea-level rise (Maspataud et al., 2018).

RESULTS

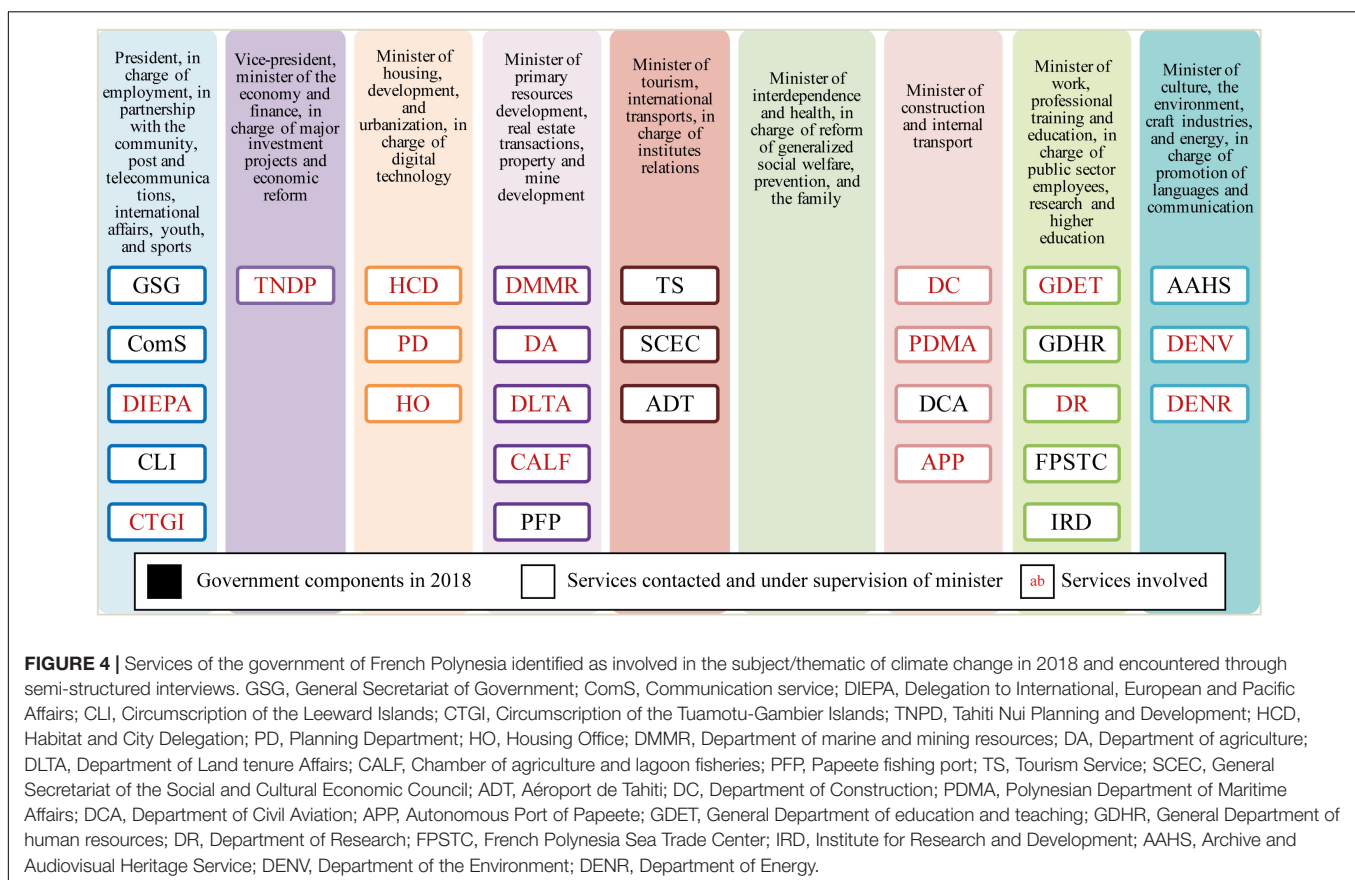
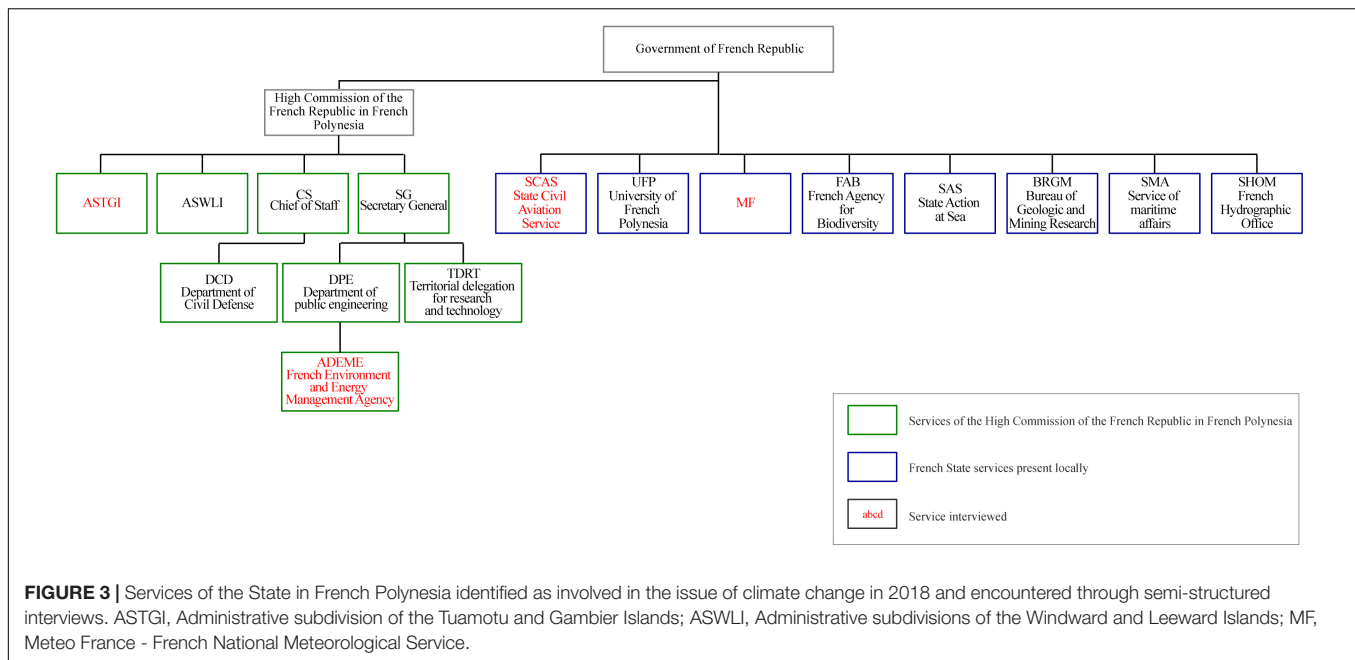
Identification of Services Related to Climate Change

A meeting proposal was sent to the heads of services identified as being involved in the area of climate change (**Figures 3, 4**).

In all, representatives of six State services and seventeen Territory services were contacted and interviewed. In some cases, the chief of service was represented by a third person or accompanied by colleagues. In the results presented below, the response is counted for each service, rather than the number of persons contributing.

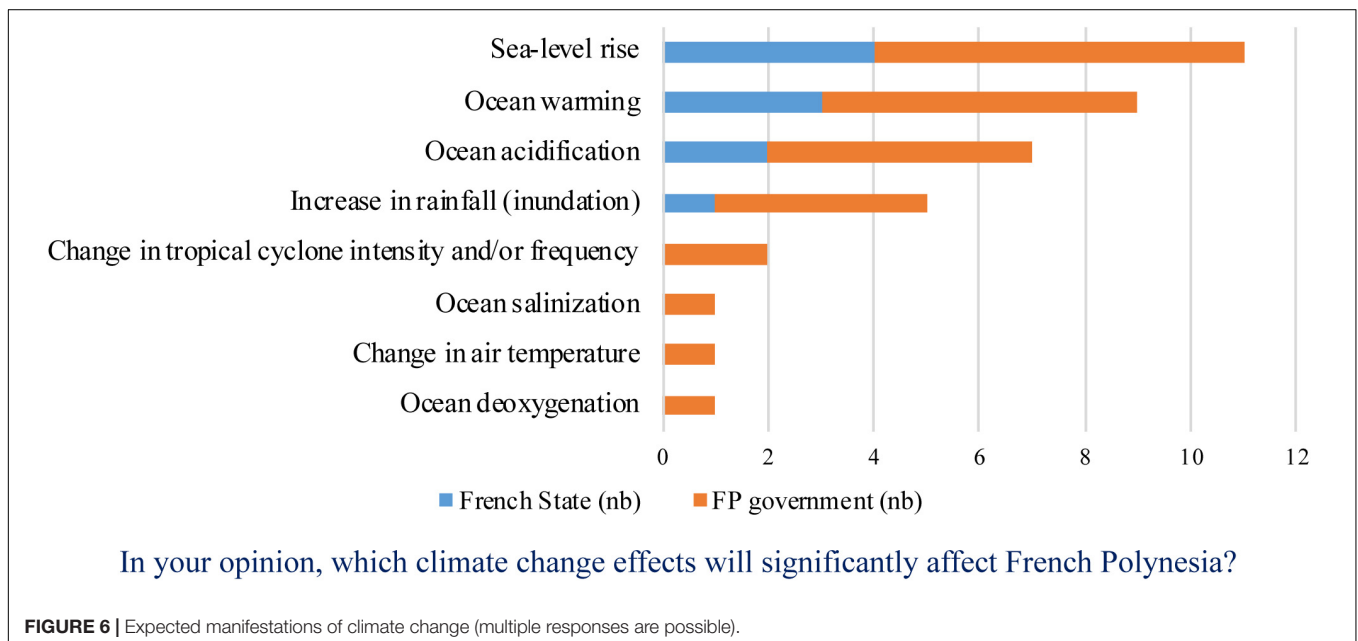
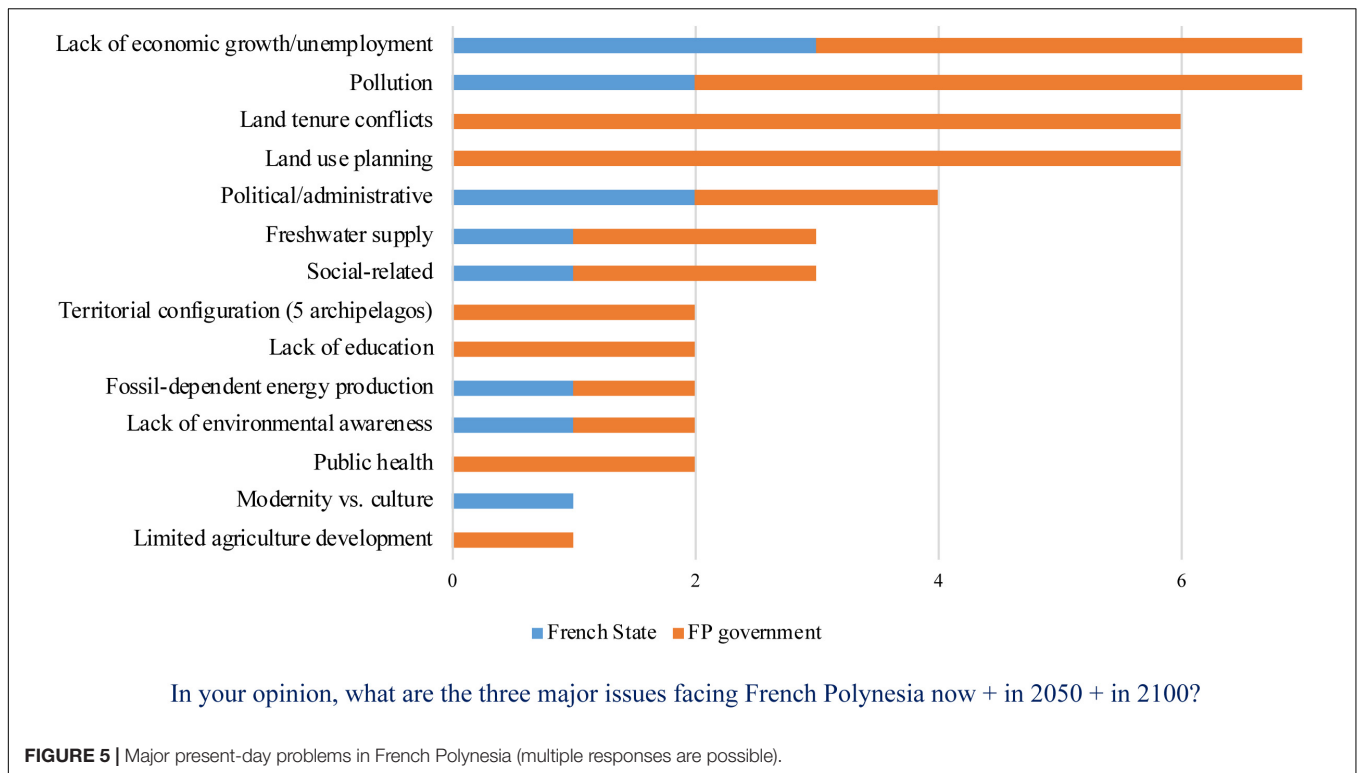
Representation of Climate Change by Institutional Actors in French Polynesia Major Problems Perceived by Institutional Actors

Problems that the interviewed institutional actors considered major are, first of all, lack of economic growth and pollution,



with 7 responses out of 23 (Figure 5). The results show that their primary concerns are environmental and socio-cultural, and related to development and management of the territory. Among environmental concerns, pollution

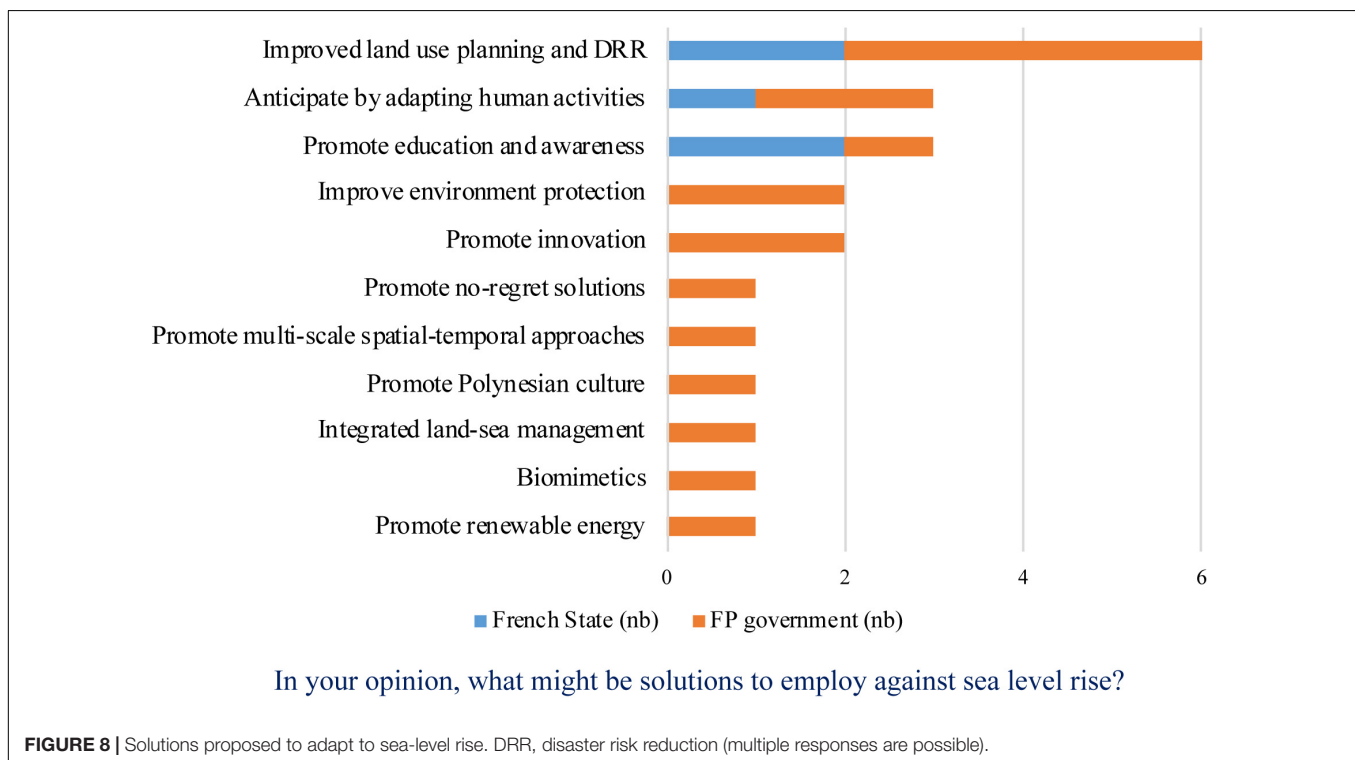
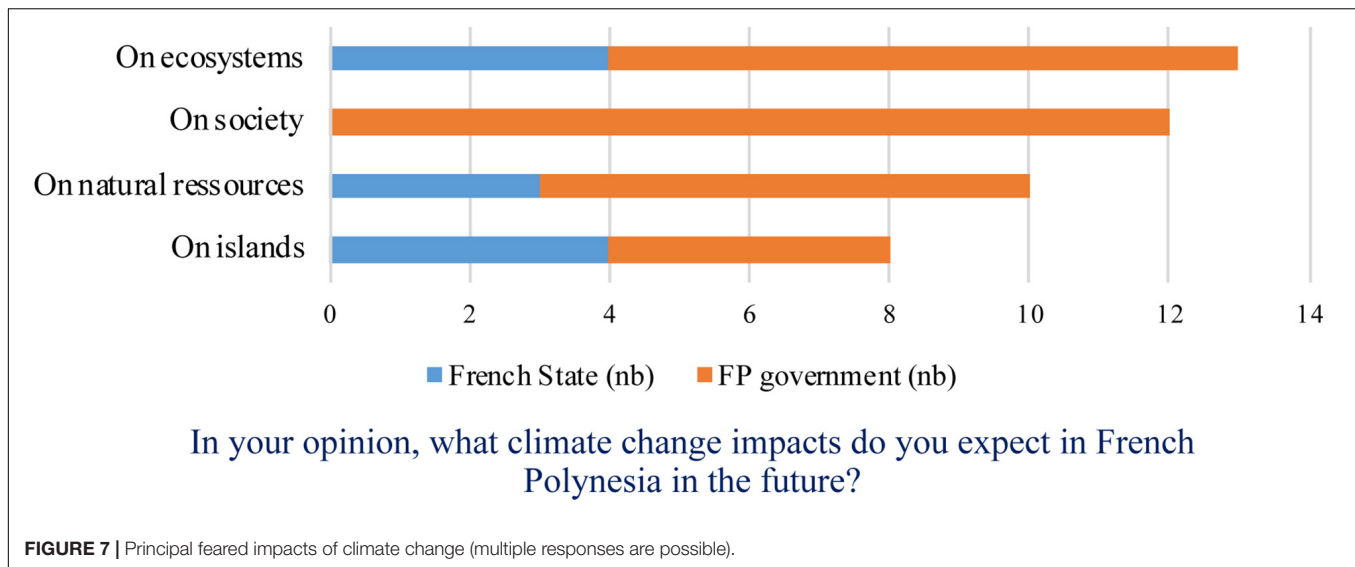
was regularly cited. Freshwater resources are also among the concerns of some interviewees, who referred to the atolls of Tuamotu Archipelago. Finally, although less cited, dependence on fossil fuel was identified as a current problem



in French Polynesia. Socio-cultural concerns are diverse; they include in particular property disputes, then to a lesser degree, social conflicts, crime, public health problems, lack of education, and even lack of sensitivity to the environment. Finally, regarding problems related to territorial development, the interviewees often referred to difficulties due to the configuration of the territory (i.e., vast and made of scattered islands). We highlight that the interviewees responded to

this question only for the present case, and not for the other timelines.

In sum, the interviewees mentioned numerous problems of a diverse nature that did not refer to climate change. They acknowledged having more important concerns than climate change in the short term, as the GDET interviewee mentioned, “*Before tackling climate change, we should tackle practical problems (waste/pollution).*” For the time being climate change



does not concern the majority of the actors interviewed. Some explain it by the absence of visible measurable and restrictive impacts to the territory, as one PDMA interviewee stated: “Climate change is not a preoccupation at the moment (...). We will become concerned when the first migrants appear”; and a PD representative “when there are manifestations (of climate change), there will be reaction.” Conversely, other actors, such as the one interviewed at DLTA, indicated observing environmental changes but without knowing if these changes were attributable to climate change: “Because of our way of life we don’t have a very heavy impact on the land but we are among the populations

that observe changes in our environment. Is it because of climate change? Because of sea-level rise? I don’t know the reasons, but we observe the fact that there is a change in our environment.” We gather from these conversations that climate change is known among the interviewees, who are also conscious that this global phenomenon will intensify in the coming years and that French Polynesia thus risks suffering more of its effects. Thus, the DLTA interviewee recognized that “(climate change is) a problem that touches the Pacific, the island States”. The PDMA representative stated that “climate change is not a concern for the moment. [...] But in the future, it will become more of a problem.”

Expected Manifestations of Climate Change

Although the interviewees did not identify climate change as a major problem, we asked them their point of view on the type of climate change manifestations that might have an important effect on their territory (**Figure 6**). Sea-level rise (9 responses out of 23), warming (9 out of 23) and ocean acidification (7 out of 23) were the most cited manifestations. Even if rising sea level was the most often mentioned manifestation, some actors, like one of the DMMR interviewees, think that the increased ocean temperature will have a greater effect than rising sea level in French Polynesia: *“The [important] parameter is temperature. If sea level rises faster than temperature, great; if temperature rises faster than sea level, that is not good.”* As this actor explained to us, some coral species are capable of growing as sea level rises, if environmental parameters (especially sea temperature, depth, turbidity) are favorable. This capability may decrease if oceanic temperature increases rapidly. In French Polynesia above 30°C, coral bleach and can die (Salvat, pers. comm).

Furthermore, five services cited flooding, referring to the heavy rain in 2017 that caused flooding on the coast of Tahiti. The interviewees remembered bridges that gave way under the pressure of high water, flooding of Tahiti's only international airport, numerous homes destroyed, and evacuees to be housed rapidly or even a young fireman who died while responding to the event. Some interviewees also mentioned tropical cyclones, and the perspective of their intensification and possible increased frequency and their effects. Overall, actors' responses show that the most anticipated manifestations of climate change are related to changes affecting the ocean. Finally, 7 of the services interviewed gave no response to this question.

Representations of Climate Change Impacts

The principal impacts expected from climate change are, in first place, impacts to ecosystems, with 13 responses (**Figure 7**). This category includes environmental degradation generally, and of the marine ecosystem in particular, with the degradation of coral reefs (6 responses out of 13) shown by bleaching and the decline of giant clams. The interviewees stressed the loss of ecosystem services provided by coral reefs. In second place, with 12 responses, are impacts to Polynesian society. Among them, impacts to economic activities were cited 8 times. Agriculture, particularly copra production, and the blue economy (giant clam production, fishing, and pearl farming) were the principal sectors cited. Furthermore, 4 services referred to climate change impacts on safety and public health, territorial management, internal migration and on the built environment, mentioning more precisely the risk of destruction of infrastructure. In third place, impacts to natural resources were listed in 10 responses. Interviewees are worried about maintenance of freshwater resources on atolls. Impacts to marine resources were also mentioned, particularly increased competition between species due to environmental changes resulting from climate change. Eight services out of 23 mentioned climate change impacts to the islands themselves (particularly coastal erosion) and increased areas at risk because of increased natural risk, particularly coastal erosion. Among the services interrogated, 10 did not respond to this question.

Detailed answers include: For impacts on ecosystems, “detrimental impacts on the reef ecosystem” (6/13), “detrimental impacts on marine ecosystems” (4/13), and “detrimental impacts on the natural environment” (3/13); For impacts on human society, “detrimental impacts on agriculture” (4/12), “detrimental impacts on the blue economy” (4/12), “improved territorial development” (1/12), “decreased island accessibility (unusable airstrips)” (1/12), “destruction of human constructions” (1/12) and “detrimental impacts on health and security” (1/12); For impacts on natural resources, “decreased freshwater supply” (4/10), “increased species competition” (3/10), “detrimental impacts on marine resources” (2/10), and “change in vegetation cycle” (1/10); For impacts on islands, “shoreline retreat/island erosion” (5/8), “increased natural risks” (2/8), and “marine flooding” (1/8).

Representations of Rising Sea Level, Its Impact, and Responses to Implement

Nine services out of 23 do not consider SLR a present-day problem in French Polynesia, versus 7 services who hold the opposite position. The opinions are thus split. Some actors are not worried by SLR, for example, the PD representative, who told us that *“as long as it doesn't have any concrete manifestation, I will question rising sea level”* or they compared French Polynesia to other territories more exposed to SLR *“there is time to spare.”* Other participants consider SLR a present-day problem, as is the case of the CTGI [Circumscription of the Tuamotu and Gambier Islands] which manages atolls of French Polynesia and is thus very sensitive to this question: *“It's already a problem. There have been worries among mayors (of the Tuamotu) who say that they are going to be climate refugees [...] they see that sea water is warming more and more.”* These results are not surprising, since we have seen, on the one hand, that climate change is not considered a major present-day problem (**Figure 5**) and on the other hand, that SLR is a climate change manifestation that may greatly affect this territory in the years to come (**Figure 6**): *“Rising sea level is not a problem today, (but) certainly [will be] in the future”* (PDMA).

Other than these responses, the interviewees had difficulty determining a date at which SLR will become a serious problem, and therefore remained vague on this subject. Regarding the places most threatened by SLR, most of them cited atoll islands (19 respondents) and low-lying coastal areas on high islands (10 respondents).

Although the participants were not able to express precisely the impacts of SLR, with the exception of the risk of flooding, some of them did, however, propose solutions to meet them (**Figure 8**). All considered that to develop the territory more sustainably, development planning, management of natural risks, and technical adaptation of buildings in particular constitute a solution to adapt to sea-level rise. The HCD representative stated: *“This climate change dimension does not involve just protecting ourselves, it calls us to better develop the territory, better define urbanization policies. Climate change must be considered in territorial development.”* Other participants shared this point of view, such as the DPE representative who said, concerning SLR,

that it would be necessary “to plan and anticipate so as to not to be subjected to it.”

According to other participants (3 respondents) it is necessary to reduce local human disturbances. In fact, if these were discussed and thought about sustainably and if they integrated SLR, SLR might have less impact. In addition, three services suggested improving education and raising the awareness of private and public stakeholders and of residents to climate change and SLR because “Protection is not innate. It has to be taught. When you know, you can protect” (GDET). In addition, improving environmental protection was proposed as a solution because, as a representative of CTGI said: “Man must work with nature, integrate nature into his environment and not work against it.” Promoting innovation in French Polynesia also played a part in actors’ suggestions: “Finding solutions by innovating (...) and why not a floating island in the lagoon, and the population stays on its island, the resources are always there” (CTGI). Moreover, actors had other ideas for reacting to SLR, such as promoting no-regret actions, biomimetics, renewable energy, or advancing Polynesian culture, as an DENR actor indicated: “refocusing on our fenua (country) would lead to better resilience.”

Finally, on the notion of temporality, not all participants agree. Some, like the DPE representative, highlighted the importance of encouraging the adoption of a global vision in time and space, “there is not a single reflection, there are many reflections at several different time scales,” whereas others, such as PDMA were nevertheless of the opinion that “we must act at our scale and reflect over the long term.” Finally, 13 services did not want to talk about solutions to implement to confront SLR.

Activities for Adaptation to Climate Change

Although climate change is not perceived as a major problem at the present for the institutional actors, they are aware of projects and actions for adapting to climate change. Solutions most often mentioned (5 services out of 23) are the Risk Prevention Plan (PPR) and the RESCCUE project (Restoration of ecosystemic services and adaption to climate change). The first is a statutory tool of the Territory that seeks to manage land use with regard to natural risks present in French Polynesia. The second is a regional project managed in French Polynesia by a service of the State, the French Agency for Biodiversity; it seeks to reinforce the resilience of the territories studied (New Caledonia and French Polynesia), that is, [the resilience] of their ecosystems and their populations with respect to climate change. Three services cited cyclone shelters and SAGE (Action plan for general development of French Polynesia). The actors in question referred to cyclone shelters on the distant islands of Tahiti, in particular the Tuamotu atolls. Not all inhabited atolls are provided with shelters. SAGE is a territorial project that seeks to define trends for territorial planning and development for the next two decades. Finally, to a lesser extent, other actions and projects were cited, such as the Management Plan for Maritime Space (PGEM) of Moorea, the energy climate plan, the strategic climate plan, and educational marine zones. Three services did not respond to this question.

Barriers to Projects of Adaptation to Climate Change

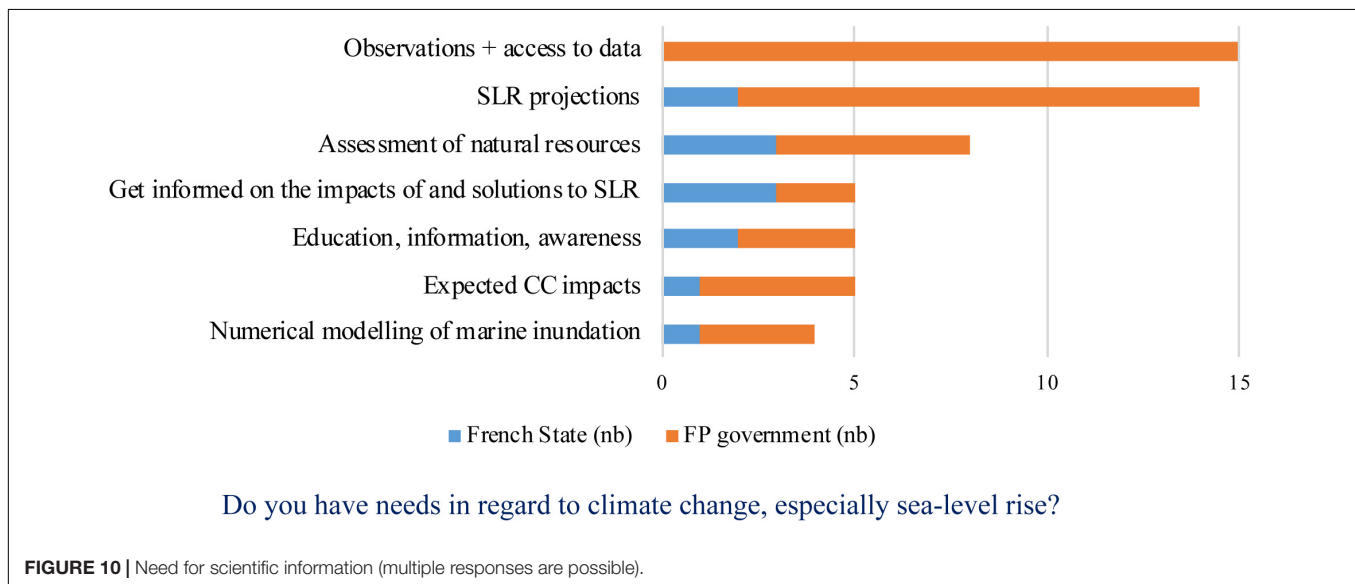
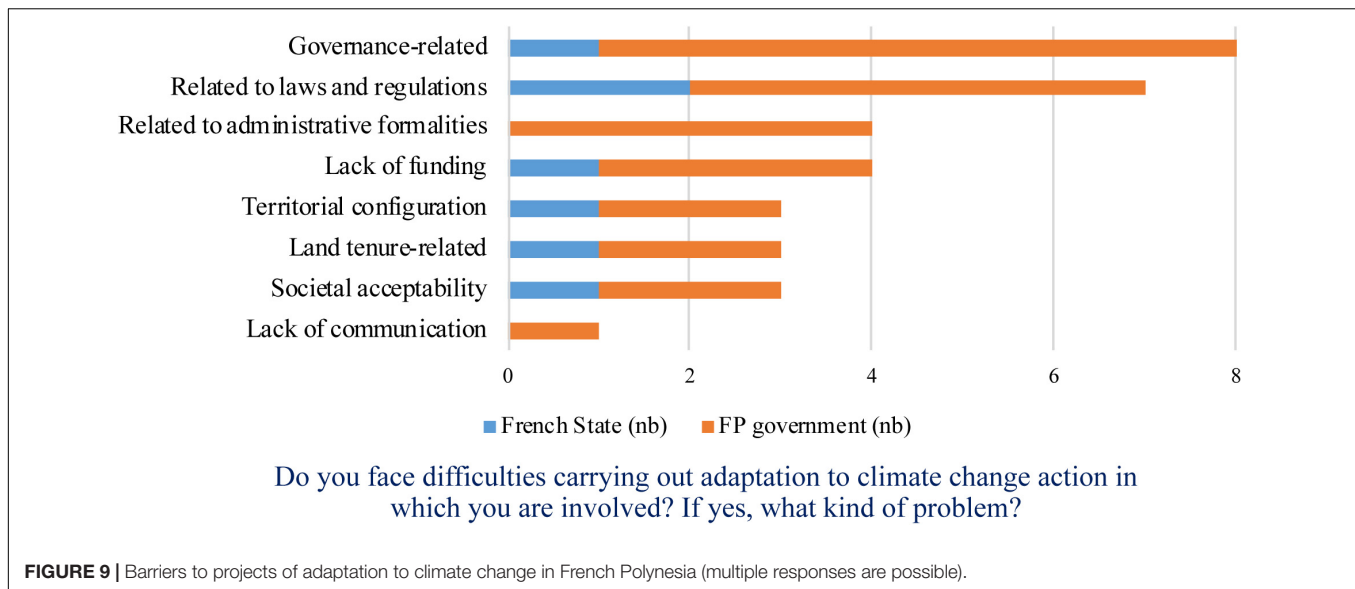
Interviewed actors identified problems of governance as the number one barrier to adaptation to climate change (Figure 9). This includes political problems, especially the regular changes of government that cause (1) a rupture in the continuity of decisions, as a TNPD representative pointed out: “Each time the government changes, planning changes”; (2) corruption of individuals leading the Territory, and (3) the lack of will dedicated to the topic of climate change. A DC representative told us that “There is no political will to go in this direction. It will be done at the last minute, when it has become urgent. It is not an easy political approach, and we are not on this approach.” According to 7 services, the second perceived barrier to climate change adaption projects is complexity of laws and regulations, in addition to administrative sluggishness, mentioned by 4 services. The third-ranking barrier to adaptation to climate change is lack of financing. Other barriers cited are distance and isolation of the islands, the land tenure system of Polynesia, problems of social acceptability (social and cultural) of projects that could modify the habits of the population. For example, a representative of DLTA explained to us that “there have been periods when the public domain has entered the private domain. It then becomes the property of individuals through definitive concessions. The coast is no longer public; it is private. It’s a major mental barrier (to action)” because any public coastal project in favor of adaptation to climate change would necessarily involve changes, for example, by *de facto* reintegrating the coastal zone into the public domain. But the inhabitants concerned refuse to renounce their privileges. In addition, according to an actor from the DENR, even if “Polynesians have a large capacity for adaptation (creative and inventive), they don’t plan for the long term” and thus imagine that a project could reap benefits over the long term. Six services did not respond to this question.

Need for Scientific Information

Most interviewees (15 services out of 23) said they are interested in scientific data related to climate, as long as it is easily accessible, standardized, and up to date (Figure 10). The actors indicated that information is not lacking, because “there is (generally) too much information” said a DC representative. On the other hand, what is necessary, according to an actor of CTGI, is “to standardize the information so that we are all talking about the same thing. And not ‘each talking according to his version,’ [because] you don’t know what he’s talking about, when you are talking about the same thing.”

In addition, 14 services showed an interest in sea level projections on a regional scale, for the territory or by archipelago, over the next decades. These projections will assist actors in their projects, and a DPE representative mentioned, “We must build in terms of sea level projections.”

The institutional actors also expressed interest in natural resource studies for the purpose of using and/or preserving these resources. The actors (5 services out of 23) also expressed the need to use information about the risks of SLR on infrastructure



and coastal construction, and for adaptations required to address these risks. Actors such as those of the CTGI are conscious that “*we are not going to limit erosion by building protection walls; that will in fact make our coasts more fragile. But for now, what is a good solution?*” Finally, the need for public awareness of climate change and its impacts in French Polynesia and modeling of marine submersion were mentioned by 4 services during interviews.

Determination of Coastal Climate Services to Develop for the Benefit of Actors

A workshop with representatives of the identified services (Figures 3, 4) included a discussion of the results obtained during the semi-structured interviews.

These exchanges made it possible to highlight subjects of concern regarding climate change and SLR among institutional actors in French Polynesia. They are: taking note of successful concrete actions, co-construct action proposals, determine the necessary conditions to guarantee the success of climate services for coastal adaptation, identify key partners to mobilize to set up case studies. An assessment of actions and policies carried out or anticipated to integrate climate change effects has been set up. Finally, topics reflected and discussed among local actors included the need for climate services with thoughts on trajectories of adaptation to global change.

The proposals formulated in this workshop were formalized across the 4 CCS: the design of SLR-compatible critical infrastructures (airports and ports); adapting to the risk of destabilization of beaches and reef islands; professional training on climate change impacts and adaptation, including the analysis

of potentially emerging new jobs in the SLR context; and the development of participatory approaches for the observation of climate change impacts.

DISCUSSION

Climate Change and Sea-Level Rise Are Not Perceived as Present-Day Problems by Institutional Actors in French Polynesia

Generally, the institutional actors interviewed feel that at this point they are protected from climate change impacts and as a result, do not consider climate change as a present-day problem. According to the literature, this result is the same throughout the Pacific territories. For example, in New Zealand, Archie et al. (2018) noticed weak engagement of the central government in policies of adaptation to and attenuation of climate change. However, and this agrees with results of our interviews (section Major Problems Perceived by Institutional Actors), Archie et al. (2018) think that the level of concern will increase over time, as climate change impacts are felt, and that this will be favorable for the implementation of actions that promote adaptation to climate change. The situation is different in Kiribati, where decision-makers are already concerned by climate change, particularly SLR (Mallin, 2018), and have already implemented policies of adaptation to climate change (e.g., Kiribati Joint Implementation Plan for Disaster Risk Management and Climate Change 2014–2023). In French Polynesia, the low level of concern among institutional actors with respect to climate change is not related to the absence of knowledge of the phenomenon and/or its impacts (Figures 6, 7).

This view of climate change is understandable if the present-day impacts of climate change are put in perspective with problems of planning and development that confront the institutional actors of French Polynesia. First of all, the morphological characteristics of islands (mountainous or low-lying) often limit territorial planning and in particular the construction of homes and infrastructure. Add to this property disputes, which are a societal problem of cultural origin. In fact, numerous plots of land are held jointly by several families who share a common ancestor. Sometimes land parcels were not claimed at the time the cadaster was done and they entered into the public domain. Today family groups claim plots on the basis of some proof. This is a general problem in French Polynesia, which pits families against each other and sometimes, private individuals against public entities (Bambridge, 2009; Charpy, 2016; Stahl, 2018).

Another example is related to the complexity of exchanges and relationships between the five archipelagos that make up French Polynesia. It must be kept in mind that French Polynesia is a territory as large as Europe. Some islands do not have aircraft landing strips, and can only be reached by boat. This isolation can cause social problems. For example, primary education is offered on each inhabited island, but middle and high school students of many islands must often leave their homes to continue their

studies on another island. As an example, in 2018 there were ten public and private high schools (general and technological, professional, and multi-purpose education) in French Polynesia. The latter are all located in the Society archipelago, including eight in Tahiti¹. In other words, only three islands have high schools, which requires high school students to travel to one of these islands to pursue their studies. It requires organization to transport these students. For example, for the 2017–2018 school year, the total amount for air transport of secondary education students (middle and high school together) exceeded 3 million €. In terms of health, the distance to some islands also poses problems, particularly for health evacuations. For example, pregnant women are highly encouraged to give birth in Tahiti (in 2004, more than 80% of births took place in Tahiti). According to the health minister, in 2018 there were more than 36,000 health evacuations within French Polynesia (separate from international health evacuations) which cost almost 16.7 million €.

The Climate Change Perception Study Helps Identify the Need for Scientific Information Related to Climate

Interviews on climate change perception of institutional actors in French Polynesia showed that they did not consider climate change to be a present-day problem, particularly because they have not yet observed impacts (section Major Problems Perceived by Institutional Actors). This is essential information, which makes it possible to identify a need for scientific information, particularly on the present-day and expected impacts of climate change in French Polynesia and to identify the CCS that will make it possible to anticipate these impacts. Smith and Mayer (2018) point out that a person who perceives climate change as a threat is more inclined to take measures to adapt to it. In addition, the semi-structured interviews and the workshop showed that institutional actors in French Polynesia were interested in knowing more about climate change impacts and requested data and localized measurements. This finding shows that there exists within French Polynesian institutions a climate favorable to changing climate change awareness toward actions seeking to remediate its impacts.

Stancioff et al. (2018) found that sometimes climate change is not perceived as a concern by societies of the Small Island Developing States and make the point that effective measures against climate change can be adopted only by considering the point of view of these societies. To “extrapolate” this to our case study, we can surmise that for effective climate change adaptation actions and projects to be implemented in French Polynesia, the perceptions of actors must be considered, since climate change is not currently one of their principal concerns. Starting from this state of affairs is crucial for planning useful climate services. Our study of climate change perception, which establishes this *status quo*, thus constitutes an important stage in the process of implementation of pertinent actions in favor of adaptation to climate change.

¹www.presidence.pf

This finding highlights the necessity of raising awareness among institutional actors in French Polynesia not only with respect to climate change and its current impacts, but also to the role that humans play in “increasing the vulnerability” of the coastal zone. Considering the implications of modalities of current planning and development in the territory with the exacerbation of future climate change impacts will help the institutional actors of French Polynesia make a connection between the problems that concern them and climate change impacts. There is probably a trigger within this process to stimulate adaptation to climate change policies. Therefore, climate service training for actors on climate change impacts may play a role. More globally, it is the role of the researcher to transmit to institutional actors the scientific knowledge that may be useful to them. For example, the study of Cuthbertson et al. (2019) on the perception of catastrophic risk in Oceania shows a gap between risk perception and real measured risk. To improve risk management, Cuthbertson et al. (2019) recommend a focus on bottom-up and educational approaches, which can be done with a strong political will and good governance practices. The CCS co-developed in French Polynesia and presented in this article incorporate such an approach.

Limitations of the Method

Interviews were generally recorded, with the agreement of interviewees. This may have been a barrier to liberty of expression of the interviewee, who represented a public service and was thus required to be consistent with the principal ideas and values communicated by the State and/or the Territory. The method used thus encouraged a politically-correct attitude.

Although we identified them as belonging to services involved in climate change, the institutional actors interrogated do not necessarily work with this subject. This explains not only why some did not respond to certain of our questions but also the results obtained with respect to their perception of climate change in French Polynesia. In addition, each service being dedicated to a specific sector (e.g., agriculture) their representatives responded to questions with a “filter,” in other words, with a specific point of view when they responded to general questions that were directed at them. For example, and logically, SLR is not a problem for agricultural fields in high islands such as Tahiti. In fact, this land is often in mountains or in a valley. This service is more interested in changes in precipitation. This explains the nature of the responses supplied by actors to the questions asked, and more globally the actor’s underestimation of certain impacts of climate change; each of the actors interrogated not being affected by the

suite of climate change impacts because of the limited domain of his activities.

LIFE SCIENCES RESEARCH INTEGRITY

Our study is based on results obtained thanks to semi-structured interviews and workshop organized with publics actors. Thus, an ethical review process was not required for our study which does not involve human subjects under no circumstances for medical research. Also, we reminded them that is a scientific study realized in the frame of INSeaPTION research project. All participants were over 16 and their anonymity is respected since no personal information allowing the identification of the interviewees is revealed.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

AUTHOR CONTRIBUTIONS

Every author of this article has contributed to its development. All contributed to data collection in the field. Interviews were conducted by HT. Results were then presented to the institutional actors of French Polynesia during a workshop led by AM in March 2018. The results were discussed during this session by VD and JO. This workshop led to the identification of four CCS.

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